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John M. Guynn

From: Randy Smith [rsmith@earthshell.com]
Sent: Saturday, September 17, 2005 6:01 PM
To: John M. Guynn
Subject: FW: Wrap Product and Process Descriptions
Attachments: WrapProductProcess-092501final.doc; Blown-MonolayerWrap-ProcessingGuidelines.doc; Deni-burgertest010907.doc; Deni-FFU MDO monolayer wrap comparison.doc; Deni-tear resistance.doc; Deni-time in motion.doc; Deni-Wrap tensile results.doc; MDO-Wrap-ProcessingGuidelines.doc; TacoBellChalupaQuiltedPaper-Specs.doc; WrapA-Papermatch-EarthshellPrint-Specs.doc

Hi John:

Here is a start.

RAS

From: Kishan Khemani
Sent: Tuesday, September 25, 2001 5:07 PM
To: Donna Balinkie
Cc: Patricia Fredlund; Per Andersen; Scott Houston; Simon Hodson; Randy Smith; John Nevling; Kishan Khemani; Lori Bowles

Subject: Wrap Product and Process Descriptions

<<WrapProductProcess-092501final.doc>> <<Blown-MonolayerWrap-ProcessingGuidelines.doc>> <<Deni-burgertest010907.doc>> <<Deni-FFU MDO monolayer wrap comparison.doc>> <<Deni-tear resistance.doc>> <<Deni-time in motion.doc>> <<Deni-Wrap tensile results.doc>> <<MDO-Wrap-ProcessingGuidelines.doc>> <<TacoBellChalupaQuiltedPaper-Specs.doc>> <<WrapA-Papermatch-EarthshellPrint-Specs.doc>>

Donna,

Please see the attached Wrap Product and Process Descriptions (ten word files) for your Wrap Book.

Deni was not able to finish her analysis of raw data today so her latest FFU report will be issued tomorrow. Product specifications tests are also underway at 'Pulp & Paper' and we are expecting data this week. Tks.

Kishan

Memorandum

Wrap Product and Process Descriptions

Current EarthShell Wrap Formulations:

(1): Monolayer Blown Film Wrap:

We have developed a papermatch-based monolayer blown film wrap suitable for cold deli sandwiches. This wrap film has only been produced on a semi-production scale blown film line at Gemini Plastics. Downstream processing (printing, slitting, sheeting etc.) has been demonstrated only on a limited basis (one company only) at Associated Poly Bag Inc.

Full production runs on commercial scale blown film lines will be done as necessary for sample production.

This wrap film has a gage of about 1.8 mils, and the formula for this wrap is 50% Biomax 4026, 35% T-4338-ES papermatch fillers and 15% Ecoflex F.

(2): Monolayer Cast Film MDO Wrap

We have also developed a papermatch based monolayer MDO wrap suitable for hot sandwiches and burgers. This wrap film has only been produced on a pilot scale cast film line at Avery Dennison. Full production run on a commercial cast-MDO film line at Avery Dennison will be done in the near future.

The formula for this wrap is the same as above, i.e. 50% Biomax 4026, 35% T-4338-ES papermatch fillers, and 15% Eastar Bio GP. The current gage of the wrap produced at the Avery Dennison pilot line is about 1.8 mils. Efforts are currently underway to schedule another trial at the same facility in order to reduce the film gage down to between 1.1-1.4 mils.

The use of machine direction orientation (MDO) in the processing of these wraps renders them more permeable to moisture and thus suitable for use with hot sandwiches.

We have not yet demonstrated the feasibility of downstream processing (printing, slitting, sheeting, perfing etc.) for this wrap, and it is an important piece of the development that still needs to happen.

Obviously, a hot sandwich wrap will also be perfectly suitable for cold sandwich applications (but not vice-versa).

FFU Test Results of EarthShell Wraps:

See the attached memorandums:

1. "Time in Motion Testing on EarthShell and Competitor Wraps", August 24, 2001
2. "FFU Wrap Comparison: Competitor Wraps and EarthShell MDO Monolayer", August 31, 2001
3. "Burger Tests on EarthShell Monolayer Wraps", September 9, 2001
4. "Tear Resistance of Sandwich Wraps", September 18, 2001
5. "Mechanical Properties of Printed Monolayer and MDO Monolayer Sandwich Wraps", September 21, 2001
6. Burger test in- and out-of-bag ***(under preparation)***
7. "Wrap WVTR Data", September, 21, 2001

Product Specifications:

See attached documents:

1. Wrap – A (Papermatch) – 'EarthShell' Print
2. Wrap – Papermatch – MDO - No Print ***(under preparation)***
3. Carl's Jr. Wax paper ***(under preparation)***
4. Taco Bell Chalupa Quilted Paper

Processing Details:

(1) See attached memorandum, " Blown Monolayer Wrap – Processing Guidelines".

(2) See attached memorandum "Monolayer MDO Wrap Film – Processing Guidelines".

Monolayer Blown Wrap Film

Processing Guidelines

Materials:

DuPont: Biomax 4026 resin containing 0.20% silica.

BASF: Ecoflex FBX resin.

A. Schulman Inc.: T4338-ES masterbatch using the Ecoflex FBX resin and $CaCO_3$ and TiO_2

Wrap Composition:

The monolayer MDO wrap consists of blowing a film from a blend of 50% T4338-ES masterbatch and 50% Biomax resin. This blend gives a final composition of 50% Biomax, 35% fillers, and 15% Ecoflex F in the finished product.

Drying:

The Biomax resin should be dried at 200°F for 10 hours to -40°F dew point or 50 ppm resin moisture level and store in sealed foil lined bags.

Equipment:

Monolayer Blown film line (Gemini Plastics, Maywood, CA, line-9):

A monolayer blown film line consisting of a 3" diameter extruder running a PE barrier screw (L/D 24/1) with a pin mixing section and a maddock shear mixing tip, a 75 HP electrical drive motor and a 8" diameter rotating die was used. The line was also equipped with a dual-lip air-ring, a chilled air supply unit and a 36" (max. width) film take-up unit with dual turret winders.

Suggested line profile for the production of Monolayer Blown Wrap film:

The extruder and downstream processing profile for the production of wrap blown films from the above mix design is noted below:

Heat Zones:	1	2	3	4	Adaptor Mixer	Rotator	Die-1	Die-2
Set °F:	350	390	400	400	390	390	390	390

Extruder pressure: 1900 psi

Tm 383 °F

Film Gage: The target gage for Monolayer wrap is between 1.1 – 2.3 mils.

EarthShell CORPORATION

Interoffice Memorandum

To: Kishan Khemani

From: Deni Miller

Date: September 9, 2001

Subject: Burger Tests on EarthShell Monolayer Wraps

Cc: Patricia Fredlund, Per Andersen, Amitabha Kumar, Randy Smith

Keywords: *Kitchen testing and results, burger test, moisture loss, meat temperature change, wraps, Carl's Jr., pinholes, monolayer, MDO*

A burger test was carried out in the lab using three different EarthShell monolayer sandwich wraps and the Carl's Jr. wax paper wrap. The EarthShell wraps tested were the printed monolayer, the MDO monolayer and the monolayer with pinholes.

In these tests, a Carl's Jr. Famous Star with no lettuce or cheese (made at the restaurant, transported to the lab and cooled to approximately room temperature) was wrapped, microwaved for 10 seconds in the McDonald's Q-ing Oven and set on the table. The weight changes and meat temperatures of the wrapped sandwiches were measured at five-minute intervals for 20 minutes. Three sandwiches were tested in each type of wrap. Each wrap was weighed dry (before the test), with condensed moisture (after the test), and with absorbed moisture (after the test and after wiping out condensed moisture). Results are shown in Tables 1 and 2, and Figures 1-3.

The Carl's Jr. wax paper wrap absorbed almost twice the moisture the EarthShell wraps absorbed. It also lost six times the moisture through the wrap as compared to the EarthShell wraps without pinholes and more than twice the moisture than the EarthShell wrap with pinholes. Consequently, this led to the Carl's Jr. wrap having two to three times the sandwich moisture loss. However, the Carl's Jr. wrap had 50-65% less condensate that the EarthShell wraps had on the interior of the wrap. In comparing the EarthShell wraps, the two wraps without pinholes performed basically the same. The wrap with pinholes had approximately the same condensed and absorbed moisture as the wraps without pinholes but had 60% more moisture lost to the atmosphere and 30% more moisture lost by the sandwich. The average meat temperature change was approximately equal in all the wraps tested.

Table 1. Average Weight and Temperature Measurements

Wrap Description	Averages for 9-07-01								Averages for 9-07-01			
	Wrap weight			Package (wrap + sandwich) weight and max. temp.								
	Wrap wt. before test	Wrap wt. change after test	Wrap wt. change after wiping	0 min	5 min	10 min	20 min		Moisture absorbed by wrap	Condensed + absorbed moisture	Moisture lost through wrap	Moisture lost by sandwich
3 Carl's Jr. Wax Paper Wraps	4.6	0.5	0.4	0.0	-0.5	-0.8	-1.5	wt. (g)	0.36	0.46	1.46	1.92
				0.0	5.2	10.0	20.1	elapsed time (min)				
				63.2	55.4	52.2	48.9	temp (°C)				
				0.0	-7.8	-11.0	-14.3	temp change (°C)				
3 MDO Monolayer Wraps	4.8	0.5	0.2	0.0	-0.1	-0.1	-0.2	wt. (g)	0.21	0.49	0.25	0.74
				0.0	5.2	10.2	20.0	elapsed time (min)				
				65.4	56.2	52.7	48.0	temp (°C)				
				0.0	-9.2	-12.7	-17.4	temp change (°C)				
3 Monolayer Printed Wraps	5.1	0.4	0.2	0.0	-0.1	-0.1	-0.2	wt. (g)	0.20	0.40	0.24	0.64
				0.0	5.4	10.0	20.2	elapsed time (min)				
				62.0	57.4	53.3	48.0	temp (°C)				
				0.0	-4.5	-8.7	-14.0	temp change (°C)				
3 Monolayer w/ Pinholes Wraps	4.4	0.4	0.2	0.0	-0.3	-0.4	-0.6	wt. (g)	0.20	0.44	0.61	1.05
				0.0	5.6	10.1	20.3	elapsed time (min)				
				59.5	56.2	51.6	46.1	temp (°C)				
				0.0	-3.3	-7.9	-13.4	temp change (°C)				

Table 2. Average Moisture Distributions

	Moisture Distribution After Test			
	Moisture condensed on wrap interior (g)	Moisture absorbed by wrap (g)	Moisture lost to atmosphere (g)	Total moisture lost by sandwich (g)
3 Carl's Jr. Wax Paper Wraps	0.10	0.36	1.46	1.92
3 MDO Monolayer Wraps	0.29	0.21	0.25	0.74
3 Monolayer Printed Wraps	0.20	0.20	0.24	0.64
3 Monolayer w/ Pinholes Wraps	0.24	0.20	0.61	1.05

Figure 1. Change in Package Weight with Time for Wrapped Carl's Jr. Sandwiches

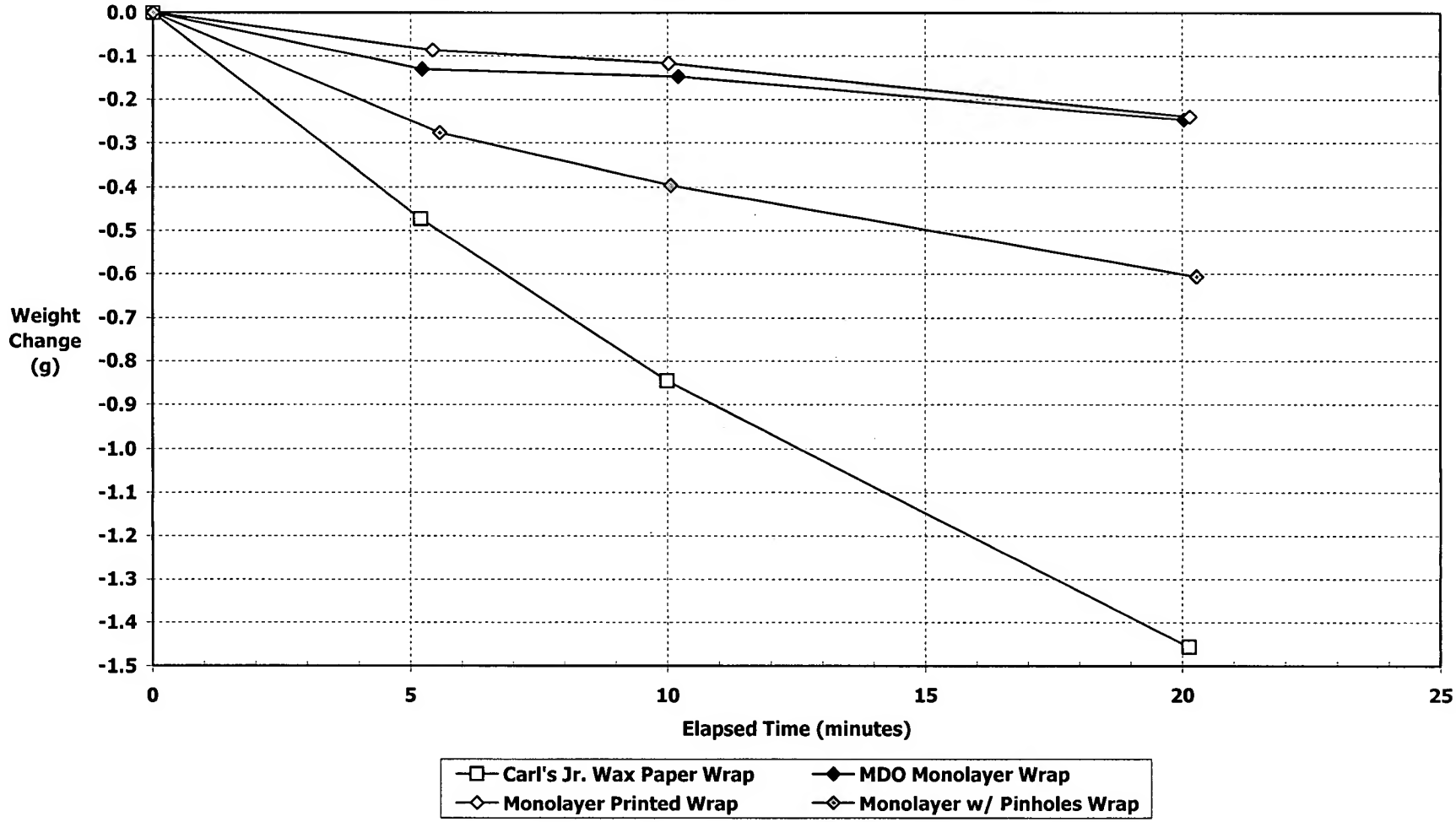


Figure 2. Change in Meat Temperature with Time for Wrapped Carl's Jr. Sandwiches

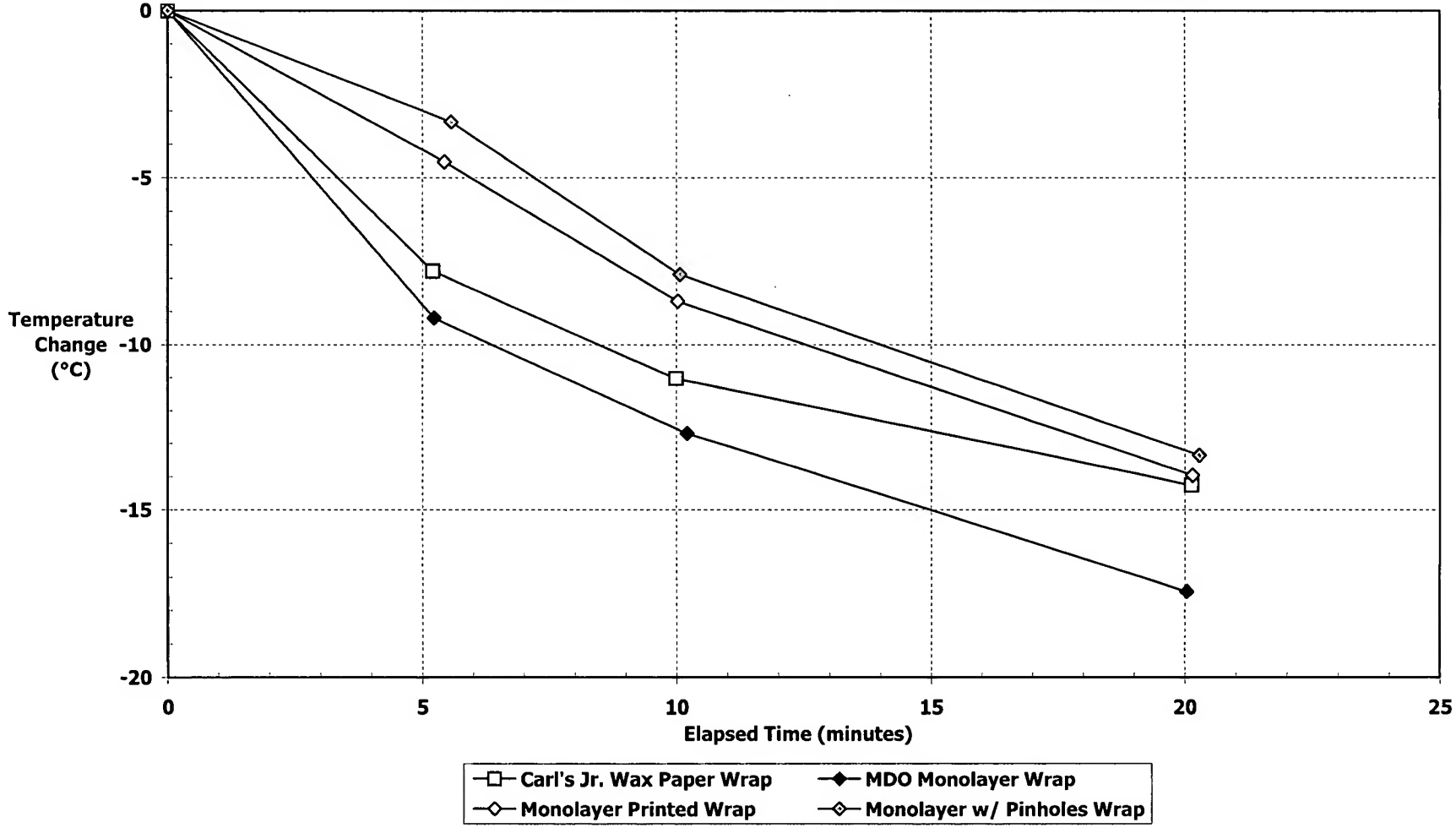
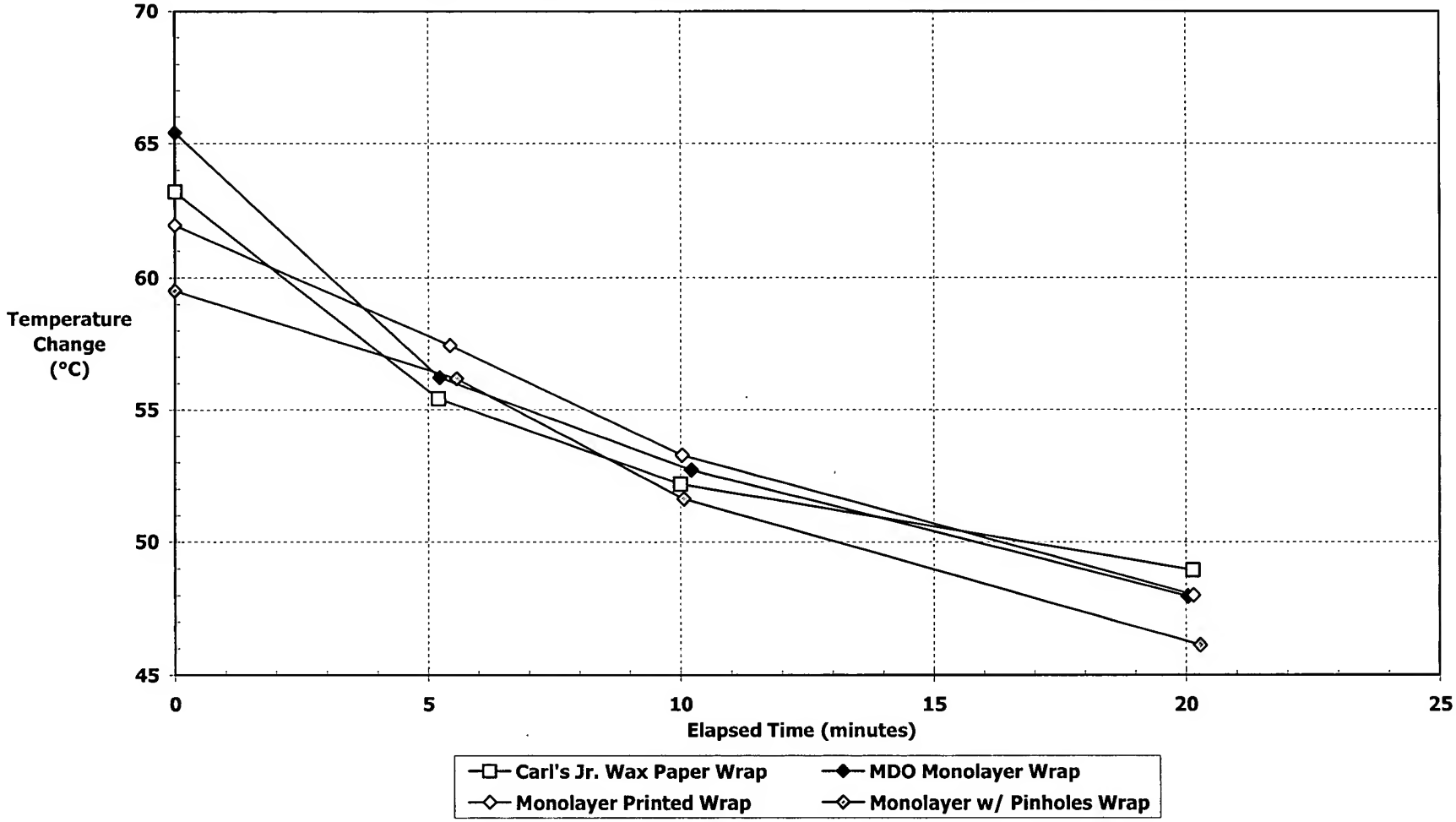


Figure 3. Variation in Temperature with Time for Wrapped Carl's Jr. Sandwiches



EarthShell CORPORATION

Interoffice Memorandum

To: Kishan Khemani, Randy Smith, John Nevling

From: Deni Miller

Date: August 31, 2001

Subject: FFU Wrap Comparison: Competitor Wraps and EarthShell MDO Monolayer

Cc: Per Andersen, Patricia Fredlund, Amitabha Kumar

Keywords: *Kitchen testing and results, FFU, burger test, moisture loss, meat temperature change, wraps, Carl's Jr., McDonald's, Wendy's, MDO monolayer, ABC 5-2, dead fold, puncture resistance, grease resistance, time in motion*

The Fitness for Use (FFU) of the EarthShell sandwich wrap MDO monolayer was compared to three competitor wraps currently being used: Carl's Jr. Wax Paper, McDonald's QPC Quilted Paper and Wendy's Foil. Data from the EarthShell ABC 5-2 wrap is also included. This report contains the results of the following FFU tests: physical dimensions, microwaveability and meat temperature/weight loss over ½ hour, grease resistance, burger test, puncture resistance, dead-fold and time in motion.

Results and Discussion

Physical Dimensions

The length, width, thickness and basis weight were measured on three wrap samples of each type of wrap. The results are shown in Table 1 and Figures 1-2. The EarthShell MDO monolayer wraps were cut to approximately the same size as the Carl's Jr. wraps, 13.0" x 14.25", and have a basis weight of 8.5 lb/1000 sq. ft which is similar to the Wendy's foil wrap. The Wendy's foil wraps are the smallest at 13" x 10.5" and the Carl's Jr. wax paper wrap are the lightest with a basis weight of 7.9 lb/1000 sq. ft.

Microwaveability and Meat Temperature/Weight Loss Over ½ Hour

A Carl's Jr. Famous Star™ with no lettuce or cheese (made at the restaurant, transported to the lab and cooled to approximately room temperature) is wrapped, microwaved for 10 seconds in the McDonald's Q-ing Oven and set on the table. The weight changes and meat temperatures of the wrapped sandwiches are measured at five-minute intervals for 20 minutes. Three sandwiches are tested in the EarthShell wrap and three in the Carl's Jr. wax paper wraps for comparison. Each wrap is weighed dry (before the test), with condensed moisture (after the test), and with absorbed moisture (after the test and after wiping out condensed moisture). Results are shown in Tables 2 and 3, and Figures 3-5.

The Carl's Jr. wax paper wrap absorbed almost twice the moisture the EarthShell MDO wrap absorbed and lost 85% more moisture through the wrap. Consequently, this led to 64% more moisture loss in the sandwiches wrapped in the Carl's Jr. wrap as compared to the EarthShell MDO wrap. The EarthShell

wrap had twice the condensate on the wrap interior than the Carl's Jr. wrap. Both wraps produced nearly the same loss in overall meat temperature of approximately 18°C in the 20 minute time period.

Grease Resistance

The Federal Grease test was performed on one of each of the five wraps tested. Both EarthShell wraps and the Wendy's foil wrap performed very well and had no penetration of the oil. The Carl's Jr. wax paper wrap and the McDonald's quilted wrap both had a very small amount of leak through. The Carl's Jr. wrap had eight grease spots of 1-3 mm in size (~ 27 mm^2 total) and the McDonald's quilted wrap had three grease spots all of approximately 3 mm in size (~ 21 mm^2 total).

Burger Test

A fresh Carl's Jr. Famous Star™ sandwich is placed in each of two wraps at the restaurant and placed in a bag together. The time is recorded on the bag and the top flap of the bag is rolled over to trap any heat and moisture that may escape the wraps. After 15 minutes, the bag is opened and the wrapped sandwiches are evaluated for sticking together, leakage, condensation, holding food together and grease show-through. After the 15 minute interval, the EarthShell wraps had a small amount of condensation on the inside of the wrap, however, the bun was not wet or soggy. There was no sticking between the two wrapped sandwiches and they held the sandwiches together well. There was also no leakage or grease show-through in either wrapped sandwich.

Puncture Resistance

The puncture resistance of five wrap samples was measured on the Instron using the testing fixture in Figure 6. Wrap samples were placed between the plates and loaded at 20 inches/minute until punctured. The maximum load and displacement at the maximum load was recorded. Table 4 includes the averages, standard deviations and minimum and maximum data. Figure 7 contains a plot of the maximum load and displacement. The average maximum load of the EarthShell MDO wrap is 1.23 ± 0.07 lb_f and the average maximum displacement is 0.40" ± 0.02". The McDonald's quilted wrap had the highest maximum load at 1.90 lb_f.

Dead Fold

A 50 gram weight is placed on a bent over strip of wrap (1" x 4") for 10 seconds. Thirty seconds after the weight is removed, the angle formed by the crease is read with a protractor. Twelve readings are taken on each of six samples cut in both the machine direction and the cross direction for a total of 24 data points for each wrap. The average percentage crease retained (C) in each direction is then calculated from C = 100*(180-A)/180 where A is the average angle formed in the crease. The raw data is reported in Table 5 and a summary of the data in Table 6. Figures 8-9 contain plots of the crease retention in both the machine and cross direction and Figure 10 shows the average crease retention. The EarthShell MDO wrap far exceeded any of the other wraps with 100% crease retention. The Wendy's foil wrap was the next closest with 77% crease retention.

Time in Motion

The time in motion test measures the time required to transfer one sandwich wrap from a wrap tree to the food preparation area and lay in a perfectly flat position. The wrap tree is 18" above the food preparation area. Twenty wraps were transferred one at a time; the time was measured for each

individual transfer and averaged. The raw data is reported in Table 7 and a plot of the average time in motion with the standard deviation is in Figure 11. The average time in motion for the EarthShell MDO wrap was slightly better than the EarthShell ABC 5-2 wrap, 1.9 ± 0.8 seconds as compared to 2.2 ± 0.8 seconds, respectively. The Wendy's foil wrap had the lowest time in motion at 1.1 ± 0.4 seconds. Also note that both the EarthShell wraps had almost twice the standard deviation than the three competitor wraps tested.

Table 1. Physical Dimensions

Wrap	Size (L x W)	Area (sq. inches)	Thickness (inches)	Basis Weight (lb./1000 sq. ft.)
Carl's Jr. Wax Paper	13.0" x 14.25"	185.25	0.0020	7.9
McDonald's QPC Quilted	13.0" x 11.5"	149.50	0.0035	9.2
Wendy's Foil	13.0" x 10.5"	136.50	0.0015	8.6
EarthShell ABC 5-2	15.0" x 15.0"	225.00	0.0016	9.8
EarthShell MDO	~ 13.0" x 14.25"	185.25	0.0030	8.5

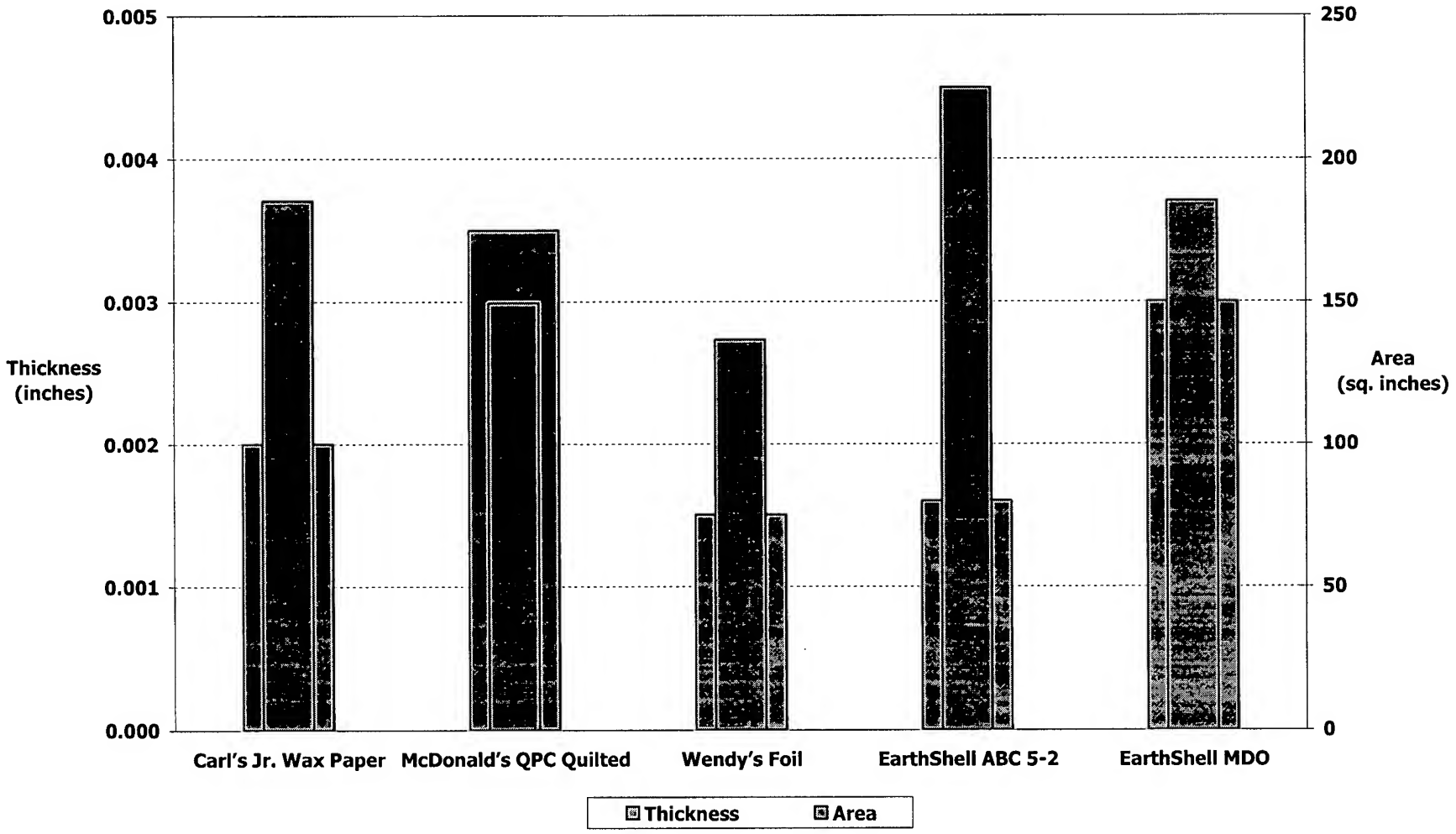


Figure 1. Thickness and Area Measurements of EarthShell and Competitor Wraps

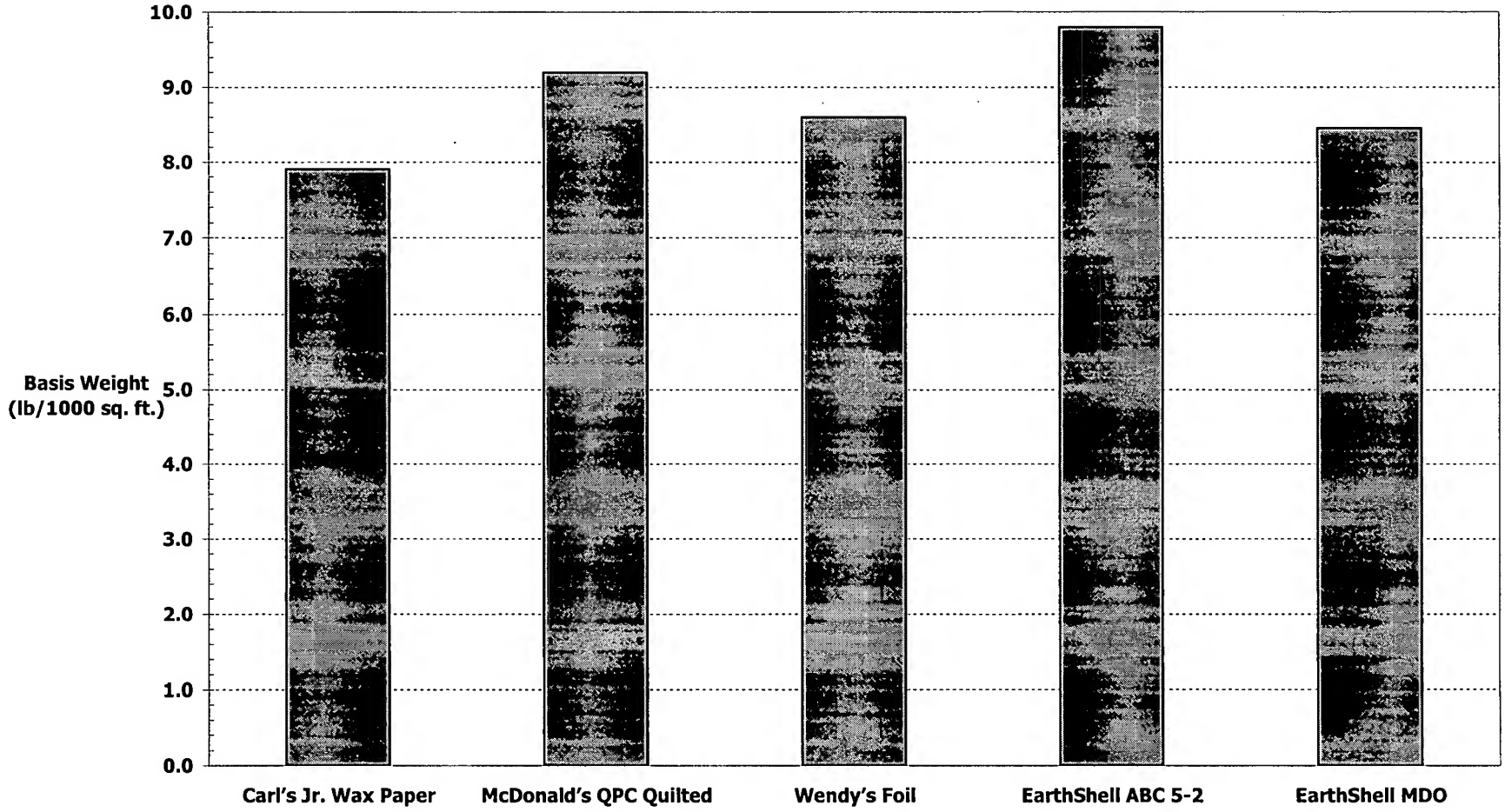


Figure 2. Basis Weight of EarthShell and Competitor Wraps

Table 2. Average Weight and Temperature Measurements

Wrap Description	Averages for 8-28-01								Averages for 8-28-01			
	Wrap weight			Package (wrap + sandwich) weight and max. temp.								
	Wrap wt. before test	Wrap wt. change after test	Wrap wt. change after wiping	0 min	5 min	10 min	20 min		Moisture absorbed by wrap	Condensed + absorbed moisture	Moisture lost through wrap	Moisture lost by sandwich
3 Carl's Jr. Wax Paper Wrap	4.6	0.5	0.4	0.0	-0.4	-0.7	-1.2	wt. (g)	0.41	0.53	1.24	1.77
				0.0	5.0	10.0	20.0	elapsed time (min)				
				62.1	55.9	50.6	44.6	temp (°C)				
				0.0	-6.3	-11.6	-17.6	temp change (°C)				
3 MDO Monolayer Wraps	5.0	0.4	0.2	0.0	-0.1	-0.1	-0.2	wt. (g)	0.19	0.45	0.19	0.64
				0.0	5.0	10.0	20.1	elapsed time (min)				
				63.7	57.9	52.3	45.2	temp (°C)				
				0.0	-5.7	-11.3	-18.5	temp change (°C)				

Table 3. Average Moisture Distributions

	Moisture Distribution After Test			
	Moisture condensed on wrap interior (g)	Moisture absorbed by wrap (g)	Moisture lost to atmosphere (g)	Total moisture lost by sandwich (g)
3 Carl's Jr. Wax Paper Wrap	0.12	0.41	1.24	1.77
3 MDO Monolayer Wraps	0.25	0.19	0.19	0.64

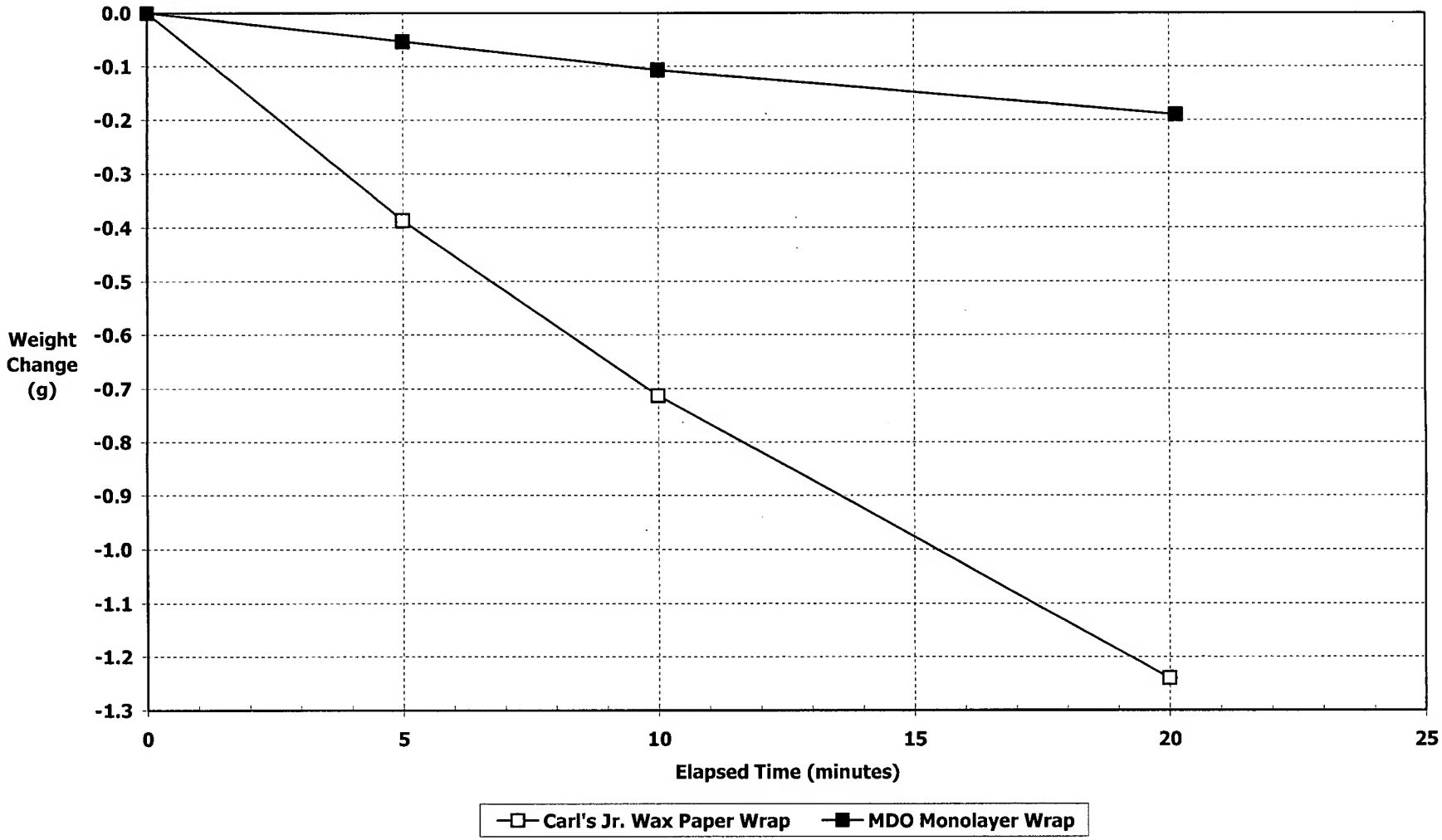


Figure 3. Change in Package Weight with Time for Wrapped Carl's Jr. Sandwiches in EarthShell and Competitor Wraps

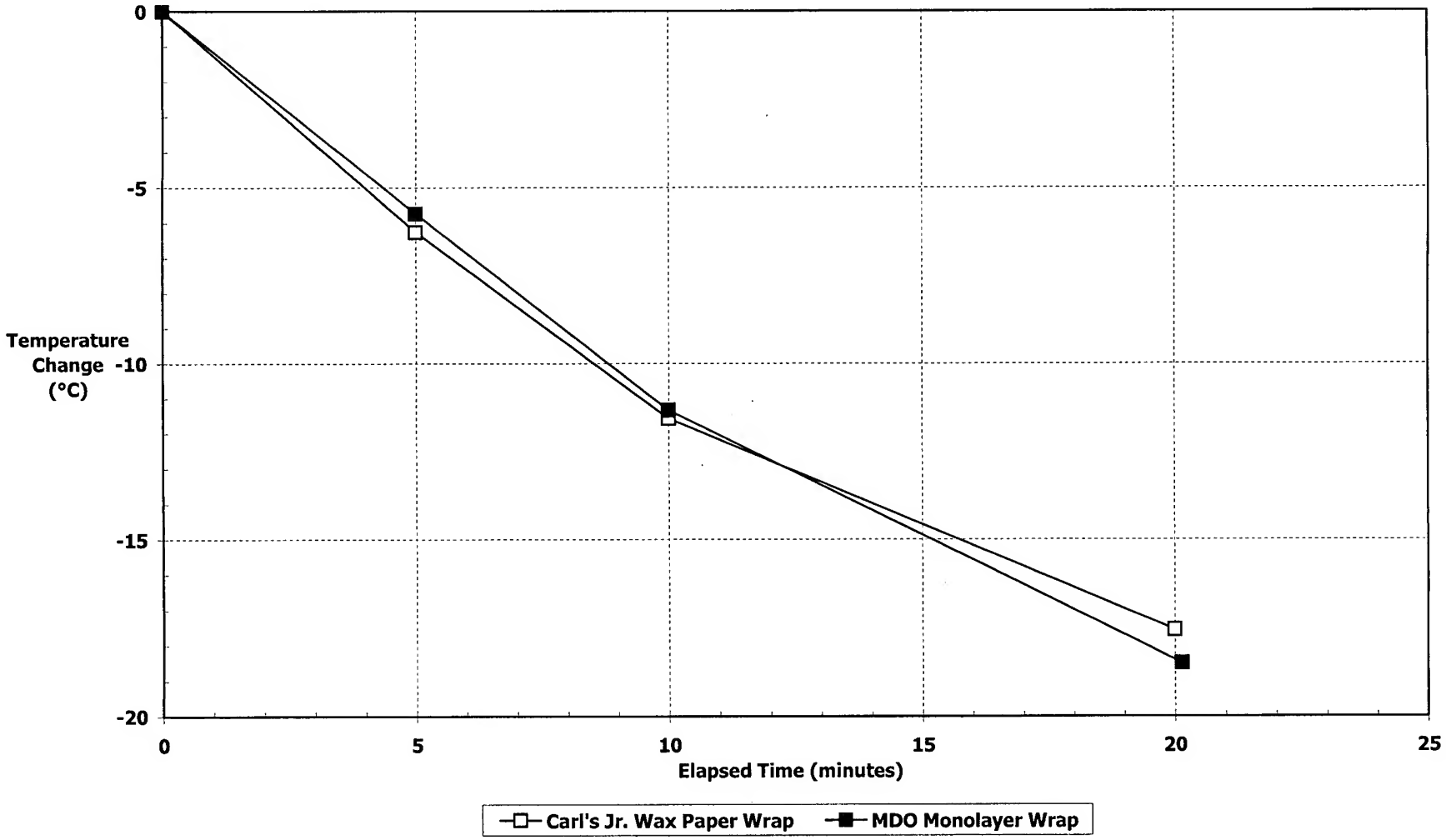


Figure 4. Change in Meat Temperature with Time for Wrapped Carl's Jr. Sandwiches in EarthShell and Competitor Wraps

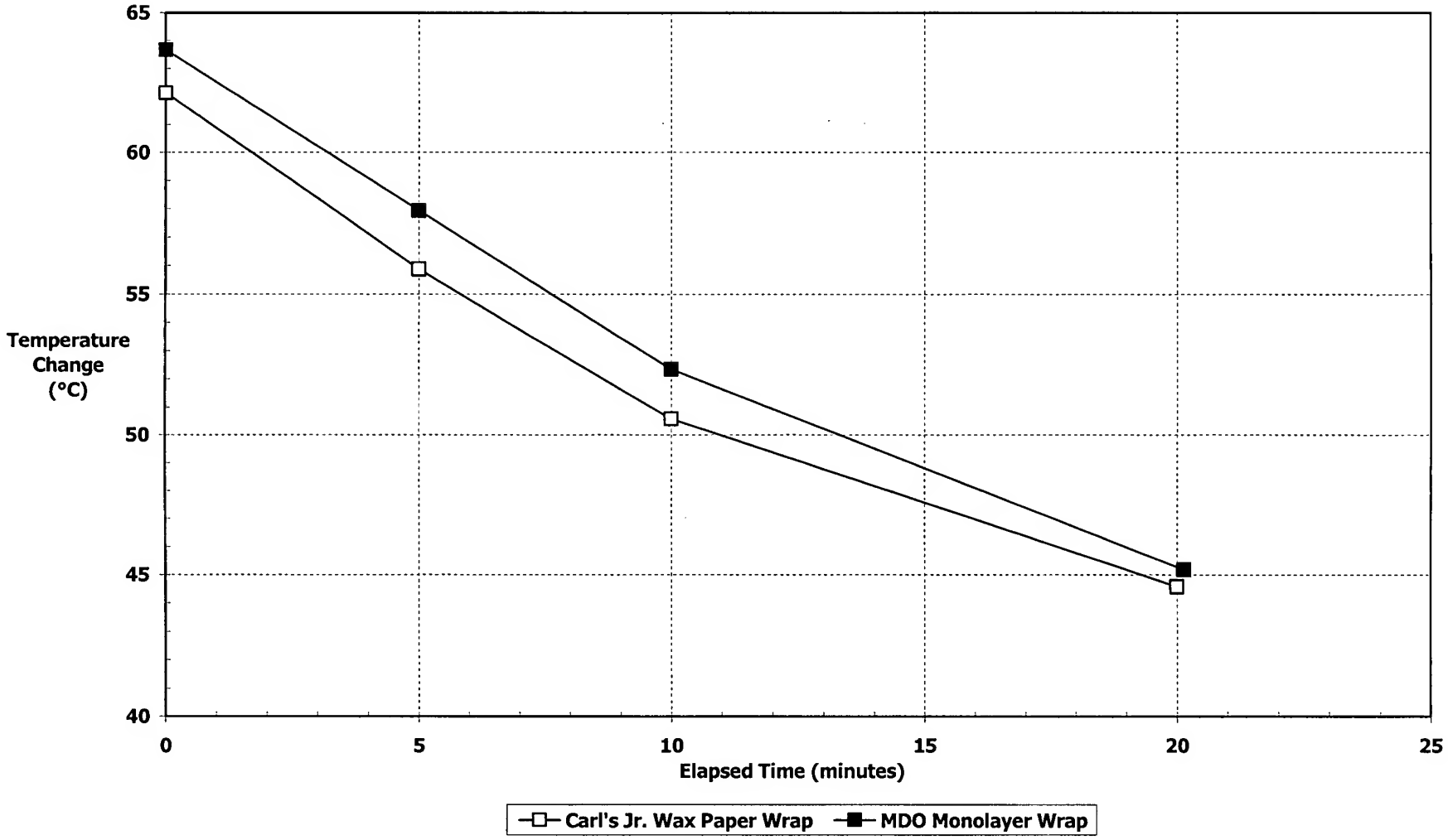


Figure 5. Variation in Temperature with Time for Wrapped Carl's Jr. Sandwiches in EarthShell and Competitor Wraps

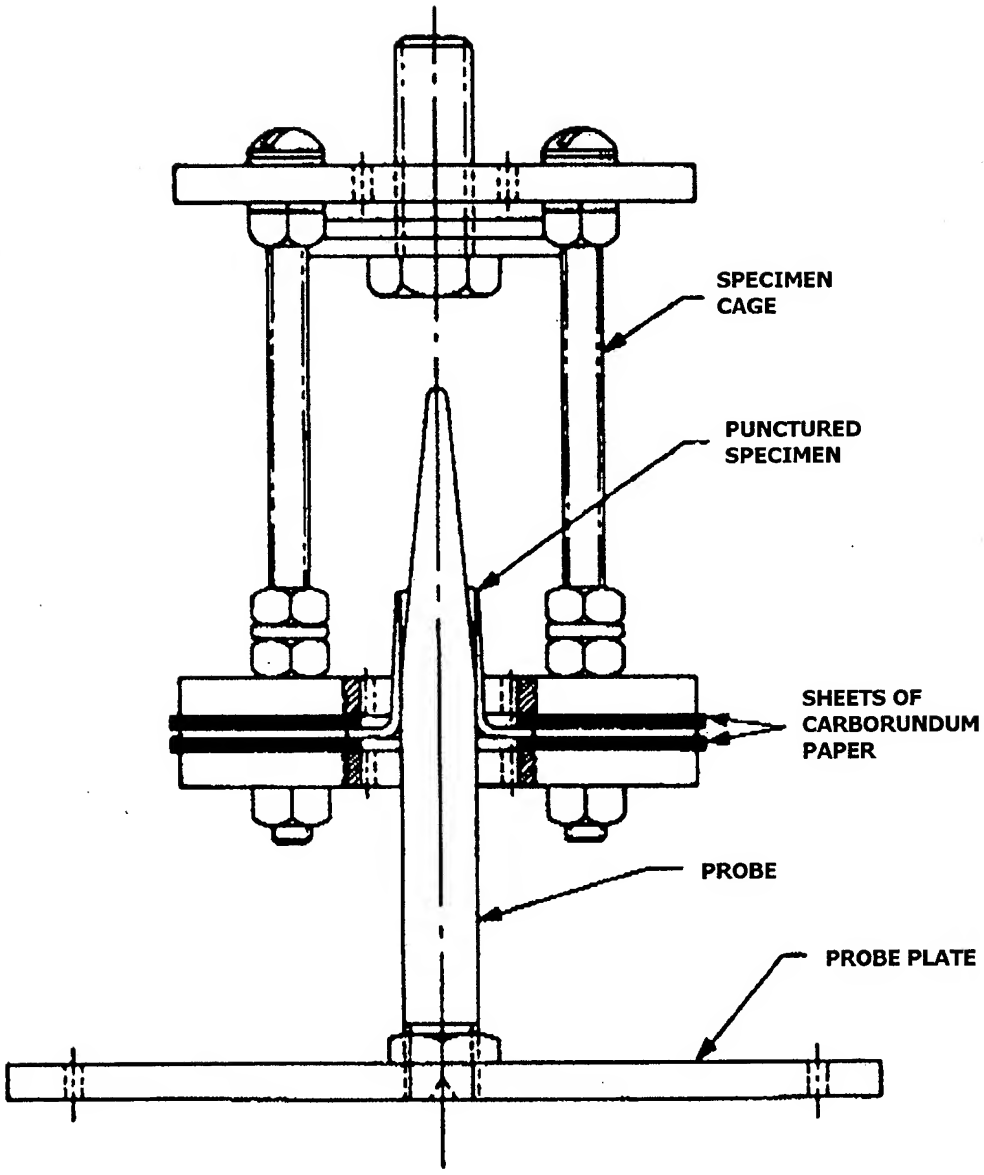


Figure 6. Puncture Resistance Test Fixture – Side View

Table 4. Puncture Resistance Data

Puncture Resistance - Average Data

Wrap	Max. Load (lb_f)	Displacement at Max Load (in.)
Carl's Jr. Wax Paper	1.25 ± 0.67	0.17 ± 0.04
McDonald's QPC Quilted	1.90 ± 0.18	0.10 ± 0.01
Wendy's Foil	1.83 ± 0.70	0.11 ± 0.02
EarthShell ABC 5-2	1.19 ± 0.04	0.29 ± 0.05
EarthShell MDO	1.23 ± 0.07	0.40 ± 0.02

Puncture Resistance - Minimum & Maximum Data

Wrap	Max. Load (lb_f)	Displacement at Max Load (in.)
Carl's Jr. Wax Paper	0.61 to 2.15	0.12 to 0.22
McDonald's QPC Quilted	1.72 to 2.11	0.09 to 0.12
Wendy's Foil	1.08 to 2.94	0.10 to 0.15
EarthShell ABC 5-2	1.15 to 1.25	0.24 to 0.36
EarthShell MDO	1.12 to 1.29	0.36 to 0.42

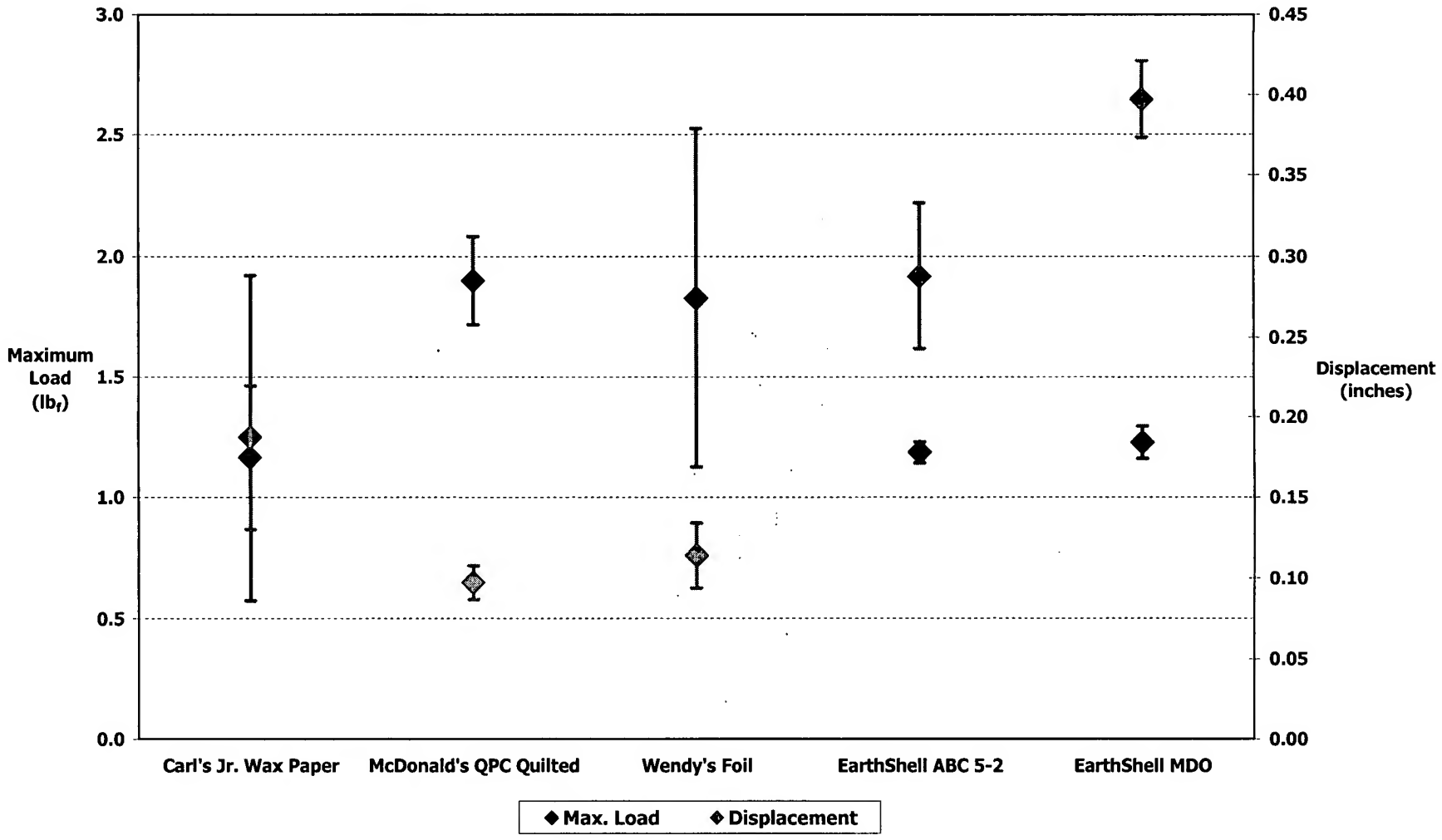


Figure 7. Puncture Resistance Maximum Load and Displacement in EarthShell and Competitor Wraps

Table 5. Dead Fold Raw Data

Direction 1 (machine)	Carl's Jr. Wax Paper	McDonald's QPC Quilted	Wendy's Foil	EarthShell ABC 5-2	EarthShell MDO
Specimen 1	80	90	50	115	0
	80	70	15	118	0
Specimen 2	70	80	50	147	0
	70	90	30	125	0
Specimen 3	80	90	60	73	0
	25	110	40	75	0
Specimen 4	60	100	50	74	0
	80	85	40	100	0
Specimen 5	60	110	20	21	0
	70	90	70	88	0
Specimen 6	80	90	60	80	0
	75	100	20	62	0
Average Angle	69.2	92.1	42.1	89.8	0.0
Crease Retained	62%	49%	77%	50%	100%

Direction 2 (cross)	Carl's Jr. Wax Paper	McDonald's QPC Quilted	Wendy's Foil	EarthShell ABC 5-2	EarthShell MDO
Specimen 1	75	115	40	94	0
	80	100	70	30	0
Specimen 2	70	90	40	108	0
	80	120	25	135	0
Specimen 3	65	120	55	15	0
	80	100	40	0	0
Specimen 4	70	110	50	70	0
	65	125	20	80	0
Specimen 5	70	130	20	145	0
	80	110	30	63	0
Specimen 6	60	120	70	73	0
	70	130	35	112	0
Average Angle	72.1	114.2	41.3	77.1	0.0
Crease Retained	60%	37%	77%	57%	100%

Table 6. Dead Fold Summary

Wrap	Direction 1 (machine)	Direction 2 (cross)	Average
Carl's Jr. Wax Paper	62% ± 9%	60% ± 4%	61% ± 7%
McDonald's QPC Quilted	49% ± 6%	37% ± 7%	43% ± 9%
Wendy's Foil	77% ± 10%	77% ± 10%	77% ± 10%
EarthShell ABC 5-2	50% ± 19%	57% ± 25%	54% ± 22%
EarthShell MDO	100% ± 0%	100% ± 0%	100% ± 0%

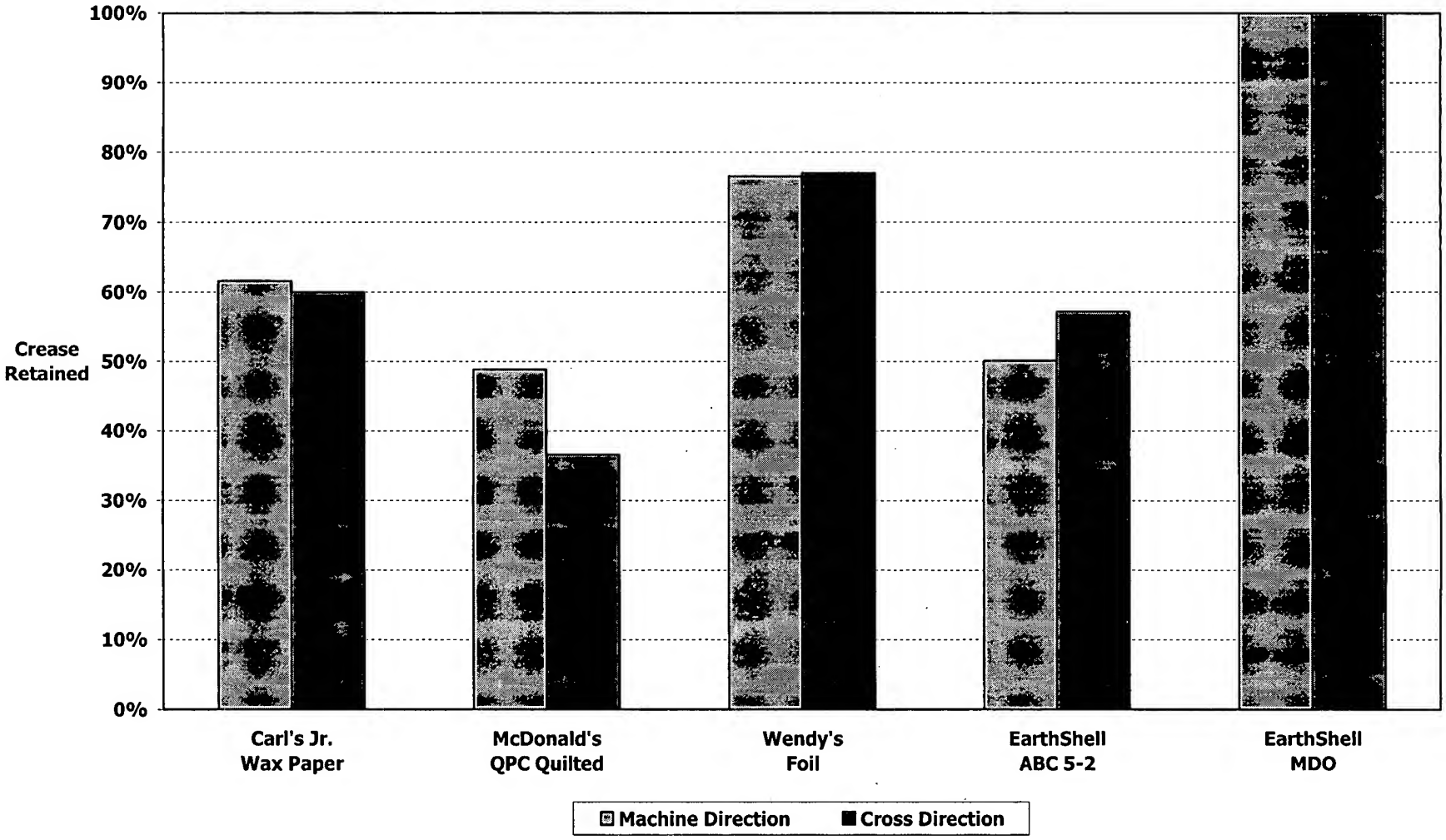


Figure 8. Crease Retention in EarthShell and Competitor Wraps

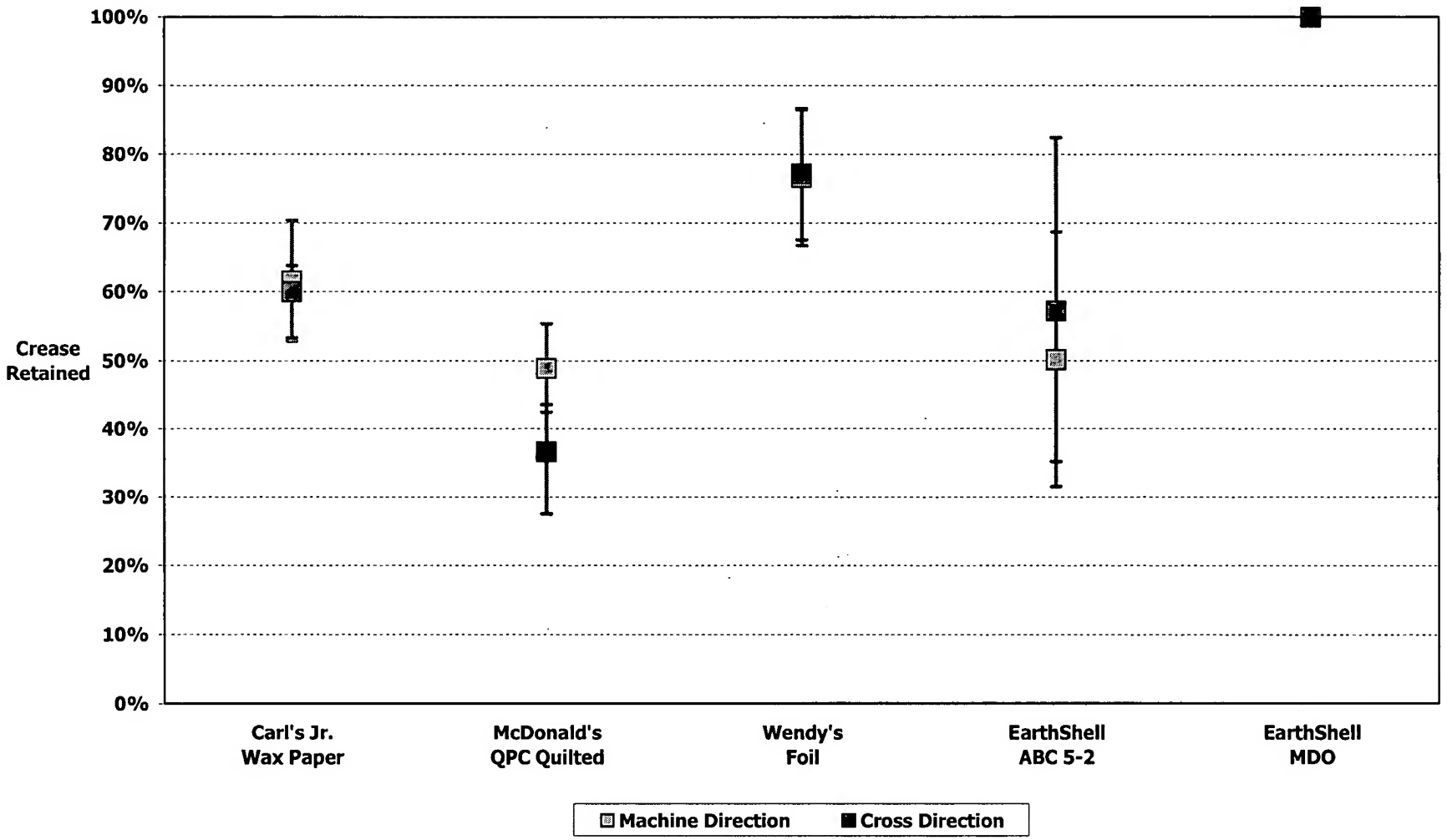


Figure 9. Crease Retention with Standard Deviations in EarthShell and Competitor Wraps

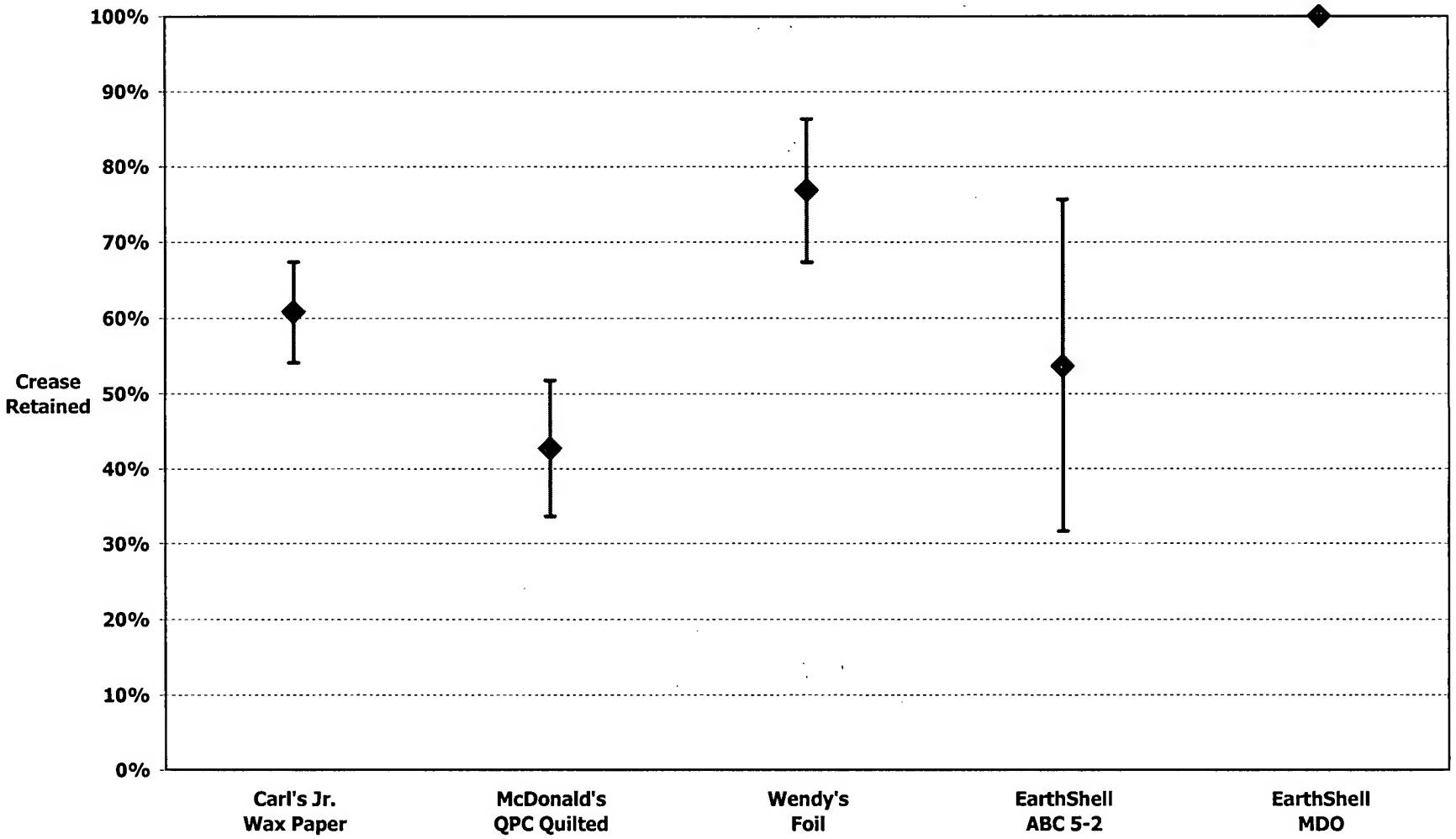


Figure 10. Average Crease Retention in EarthShell and Competitor Wraps

Table 7. Time in Motion Raw Data and Averages

Sample	Carl's Jr. Wax Paper (seconds)	McDonald's QPC Quilted (seconds)	Wendy's Foil (seconds)	EarthShell ABC 5-2 (seconds)	EarthShell MDO (seconds)
1	1.26	0.98	0.89	1.96	1.82
2	1.14	0.42	0.90	1.97	4.17
3	0.91	0.58	1.15	2.17	2.80
4	1.29	1.86	1.63	2.14	2.89
5	1.37	1.67	1.00	1.79	1.76
6	1.03	1.28	0.86	2.02	1.80
7	2.12	1.55	1.11	2.40	1.95
8	1.61	0.90	1.07	1.76	1.06
9	1.57	1.08	1.94	1.80	1.42
10	1.74	2.25	1.35	1.63	1.67
11	1.15	1.21	1.06	2.22	1.26
12	0.85	2.11	1.03	4.09	1.49
13	2.10	1.48	1.11	2.91	1.84
14	1.44	1.53	0.58	2.74	1.23
15	2.41	0.98	0.73	2.48	1.50
16	1.25	1.48	0.46	1.74	1.17
17	0.91	1.00	0.66	1.71	1.77
18	1.41	1.87	2.01	3.90	2.28
19	1.15	1.17	1.25	1.56	1.51
20	0.64	1.25	1.26	0.80	2.83
Average	1.37	1.33	1.10	2.19	1.91
St. Dev.	0.46	0.48	0.40	0.77	0.76
Minimum	0.64	0.42	0.46	0.80	1.06
Maximum	2.41	2.25	2.01	4.09	4.17

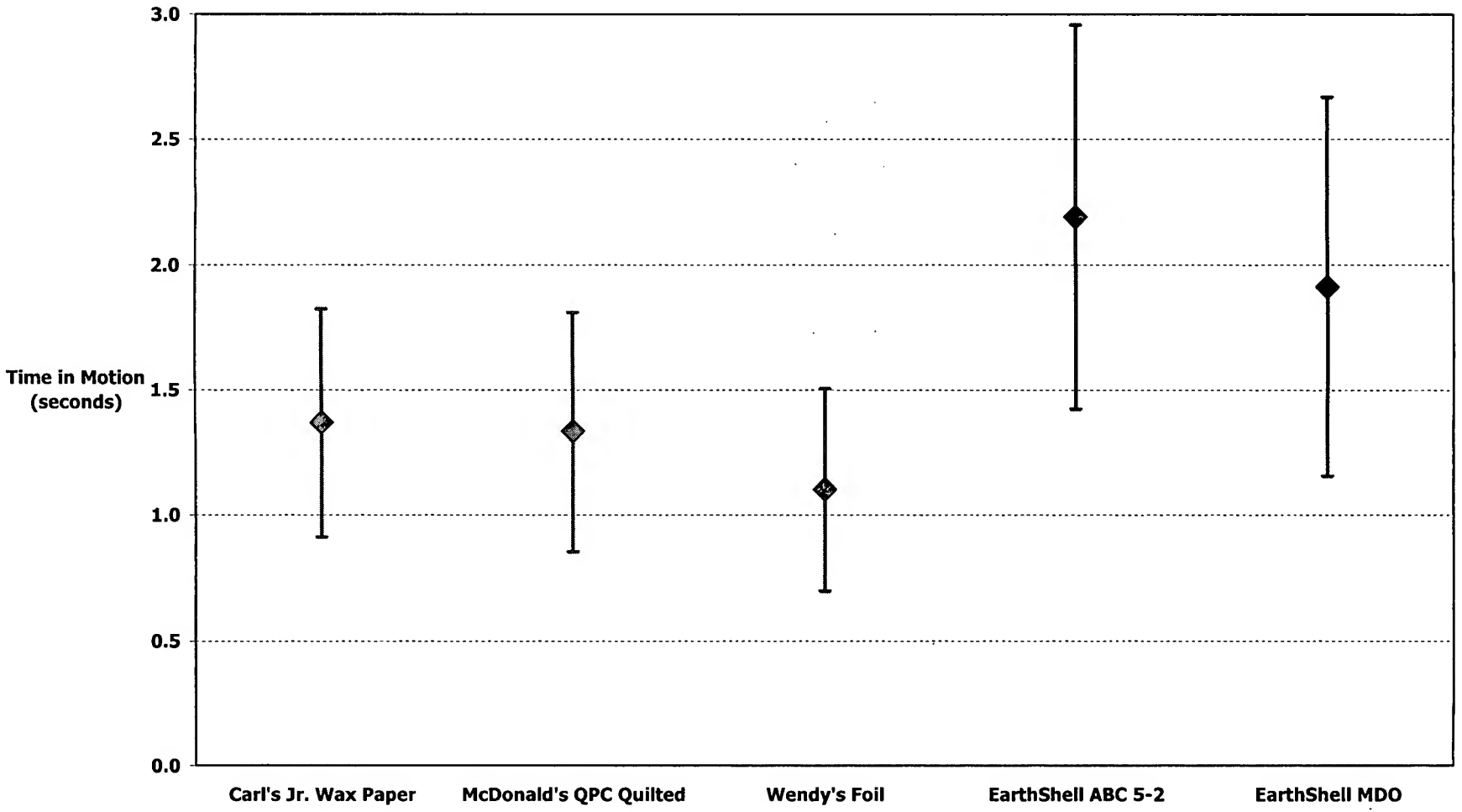


Figure 11. Time in Motion of EarthShell and Competitor Wraps

EarthShell CORPORATION

Interoffice Memorandum

To: Kishan Khemani

From: Deni Miller

Date: September 18, 2001

Subject: Tear Resistance of Sandwich Wraps

Cc: Per Andersen, Patricia Fredlund, Amitabha Kumar, Randy Smith

Keywords: *tear resistance, wraps, Carl's Jr., ABC 5-2, monolayer, AB 6-4, MDO*

A tear resistance test was performed on four EarthShell wraps and the Carl's Jr. wax paper wrap. The EarthShell wraps tested were the ABC 5-2, AB 6-4, the printed monolayer and the MDO monolayer.

The tear resistance of the wraps is measured with the initial tear resistance test of plastic film (ASTM D 1004). Using a die, four-inch long specimens are stamped out and placed in grips that are one inch apart. A tearing rate of 2"/minute is used and the maximum force to tear the specimen is recorded. Three specimens from both the machine and cross directions of each wrap were tested and averaged. All specimens were tested after conditioning at 23°C and 50% RH for 40 hours.

The Carl's Jr. wrap has the highest tear resistance of the wraps tested, 4.13 Newtons. The EarthShell wrap with the highest tear resistance is the ABC 5-2 at 3.09 Newtons, and very close behind is the printed monolayer wrap at 2.96 Newtons. The lowest tear resistance was in the AB 6-4 wrap at 1.47 Newtons. Table 1 contains a summary of the data and the average tear resistance is plotted in Figure 1.

Table 1. Data Summary

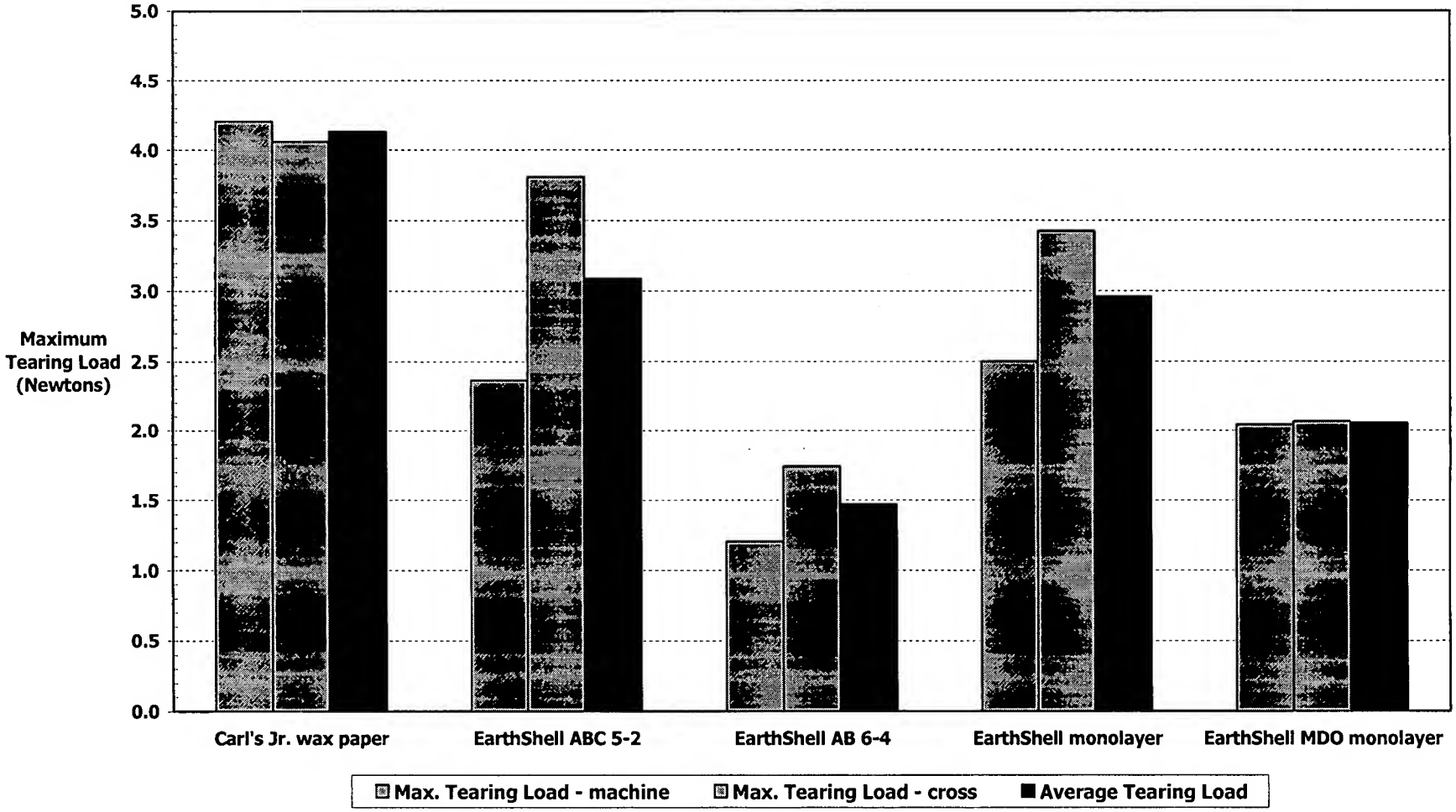
Average Data

Wrap	Max. Tearing Load - machine (Newtons)	Max. Tearing Load - cross (Newtons)	Average Tearing Load (Newtons)
Carl's Jr. wax paper	4.21 ± 1.00	4.06 ± 0.99	4.13
EarthShell ABC 5-2	2.36 ± 0.29	3.81 ± 0.04	3.09
EarthShell AB 6-4	1.20 ± 0.06	1.74 ± 0.54	1.47
EarthShell monolayer	2.50 ± 0.07	3.42 ± 0.11	2.96
EarthShell MDO monolayer	2.04 ± 0.10	2.06 ± 0.29	2.05

Minimum & Maximum Data

Wrap	Tearing Load - machine (Newtons)	Tearing Load - cross (Newtons)	Average Tearing Load (Newtons)
Carl's Jr. wax paper	3.08 to 4.97	3.46 to 5.21	3.08 to 5.21
EarthShell ABC 5-2	2.13 to 2.69	3.78 to 3.85	2.13 to 3.85
EarthShell AB 6-4	1.16 to 1.26	1.17 to 2.25	1.16 to 2.25
EarthShell monolayer	2.41 to 2.56	3.33 to 3.55	2.41 to 3.55
EarthShell MDO monolayer	1.93 to 2.12	1.73 to 2.27	1.73 to 2.27

Figure 1. Maximum Tearing Load Comparison in Wraps



EarthShell CORPORATION

Interoffice Memorandum

To: John Nevling, Kishan Khemani, Randy Smith

From: Deni Miller

Date: August 24, 2001

Subject: Time in Motion Testing on EarthShell and Competitor Wraps

Cc: Per Andersen, Patricia Fredlund, Amitabha Kumar, Donna Balinke

Keywords: *FFU, time in motion, wraps, Carl's Jr., Wendy's, McDonald's quilted, ABC 5-2*

The time in motion test was performed on two different EarthShell wraps and various competitor wraps from Carl's Jr., McDonald's and Wendy's. The wraps were tested both as received (their normal sizes) and cut to the same size.

The time in motion test measures the time required to transfer one sandwich wrap from a wrap tree to the food preparation area and lay in a perfectly flat position. The wrap tree is 18" above the food preparation area. Twenty wraps are transferred one at a time; the time is measured for each individual transfer and averaged. The following table includes the wraps tested and their sizes:

Wrap	Size (L x W)	Area (sq. inches)	Thickness (inches)	Basis Weight (lb./1000 sq. ft.)
Carl's Jr. Wax Paper	13.0" x 14.25"	185.25	0.0020	7.9
McDonald's QPC Quilted	13.0" x 11.5"	149.50	0.0035	9.2
Wendy's Foil	13.0" x 10.5"	136.50	0.0015	8.6
EarthShell ABC 5-2	15.0" x 15.0"	225.00	0.0016	9.8
EarthShell monolayer printed	15.0" x 15.0"	225.00	0.0025	7.8

For the same size wrap test, the wraps were all cut to the size of the Wendy's foil wrap, 13.0" x 10.5". The EarthShell ABC 5-2 wrap was not available in the 13.0" x 10.5" size so the EarthShell monolayer 4338 printed wrap was cut to size as an alternative.

The raw data is reported in Tables 1-2 and is plotted in Figures 1-3. The data indicates that the time in motion is not affected by the size of the wrap. The EarthShell wraps have higher standard deviations than the competitor wraps and, on the average, have approximately one second higher time in motion.

Table 1. Time in Motion Raw Data – As Received Wraps

Sample	Carl's Jr. Wax Paper (seconds)	McDonald's QPC Quilted (seconds)	Wendy's Foil (seconds)	EarthShell ABC 5-2 (seconds)
1	1.26	0.98	0.89	1.96
2	1.14	0.42	0.90	1.97
3	0.91	0.58	1.15	2.17
4	1.29	1.86	1.63	2.14
5	1.37	1.67	1.00	1.79
6	1.03	1.28	0.86	2.02
7	2.12	1.55	1.11	2.40
8	1.61	0.90	1.07	1.76
9	1.57	1.08	1.94	1.80
10	1.74	2.25	1.35	1.63
11	1.15	1.21	1.06	2.22
12	0.85	2.11	1.03	4.09
13	2.10	1.48	1.11	2.91
14	1.44	1.53	0.58	2.74
15	2.41	0.98	0.73	2.48
16	1.25	1.48	0.46	1.74
17	0.91	1.00	0.66	1.71
18	1.41	1.87	2.01	3.90
19	1.15	1.17	1.25	1.56
20	0.64	1.25	1.26	0.80
Average	1.37	1.33	1.10	2.19
St. Dev.	0.46	0.48	0.40	0.77
Minimum	0.64	0.42	0.46	0.80
Maximum	2.41	2.25	2.01	4.09

Table 2. Time in Motion Raw Data – Same Size Wraps

Sample	Carl's Jr. Wax Paper (seconds)	McDonald's QPC Quilted (seconds)	Wendy's Foil (seconds)	ES monolayer 4338 printed (seconds)
1	0.80	0.77	1.19	2.21
2	0.97	1.11	1.39	2.02
3	1.12	1.21	1.00	3.25
4	1.31	1.68	1.26	1.58
5	1.77	1.42	1.33	1.95
6	1.67	1.25	1.42	1.50
7	1.59	1.27	1.27	1.34
8	1.64	1.08	1.58	2.21
9	0.96	0.96	0.76	1.68
10	0.74	1.00	1.15	1.96
11	1.43	1.20	1.38	1.99
12	1.39	0.82	1.57	1.75
13	1.28	1.39	1.92	3.55
14	0.68	1.44	1.43	2.09
15	1.07	1.40	1.50	1.78
16	1.33	0.99	0.89	1.62
17	1.90	0.91	1.40	1.95
18	1.59	0.80	0.76	5.93
19	1.01	1.22	1.21	1.00
20	0.55	1.23	1.22	1.62
Average	1.24	1.16	1.28	2.15
St. Dev.	0.39	0.24	0.28	1.06
Minimum	0.55	0.77	0.76	1.00
Maximum	1.90	1.68	1.92	5.93

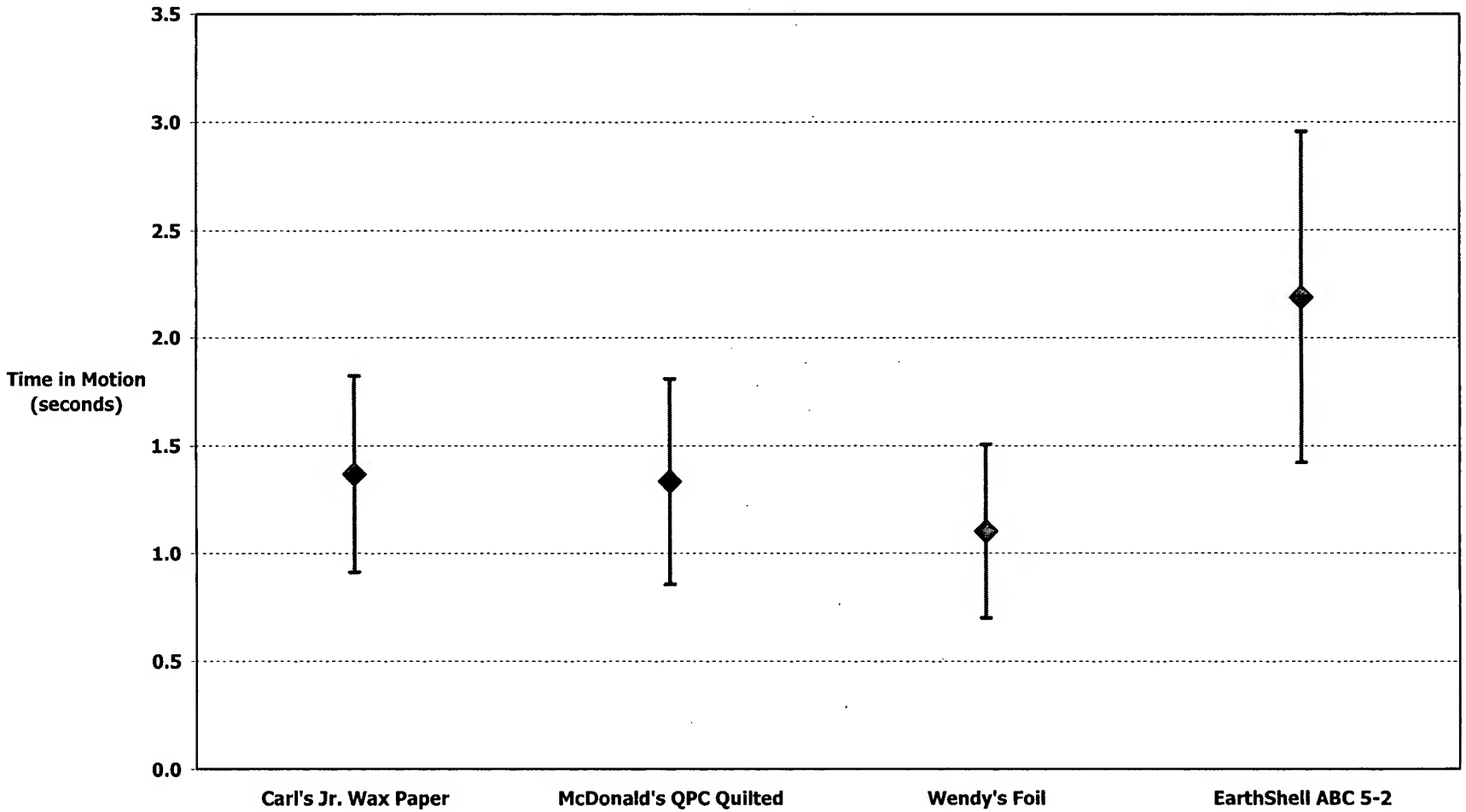


Figure 1. Time in Motion of EarthShell and Competitor Wraps As Received

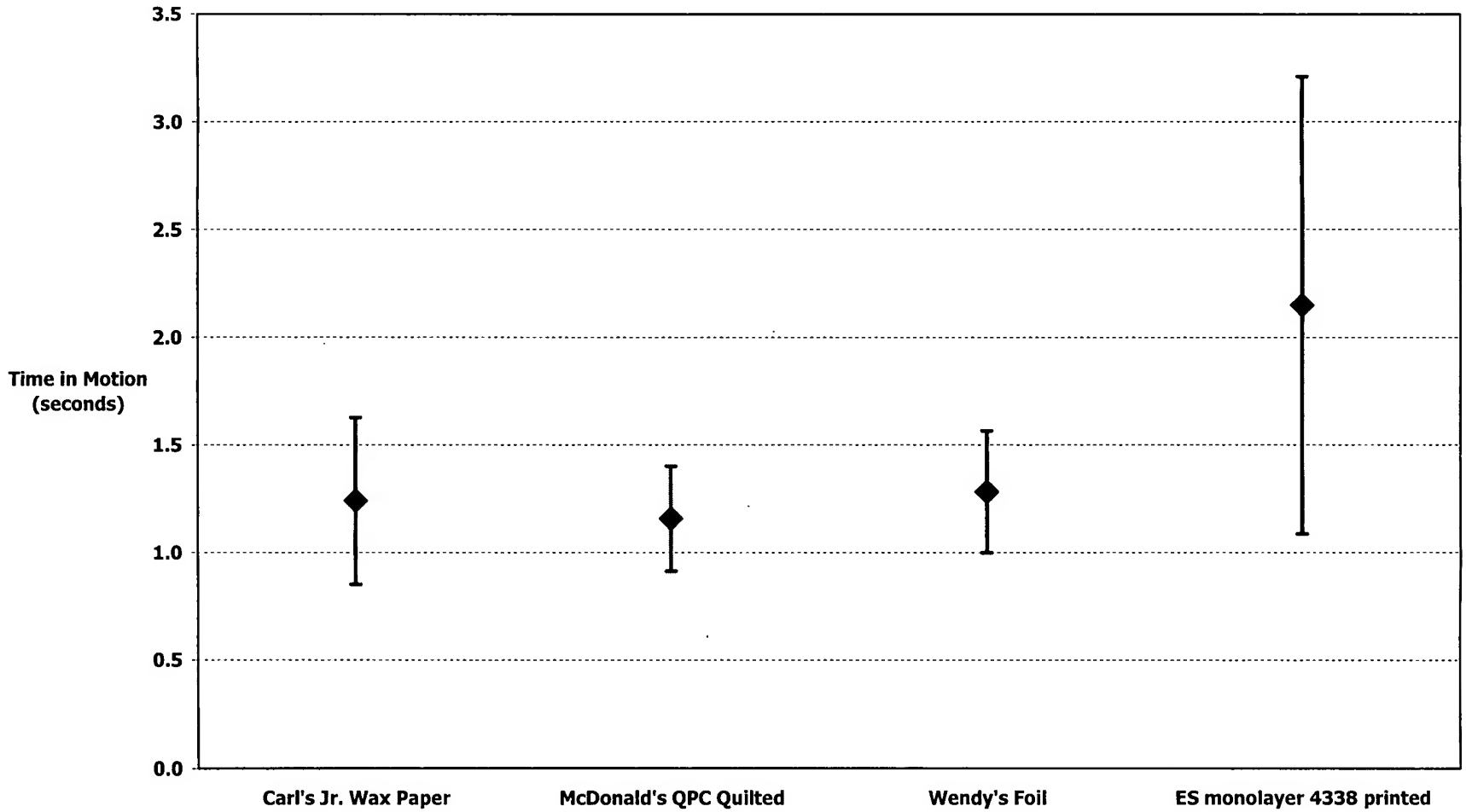


Figure 2. Time in Motion of EarthShell and Competitor Wraps Same Size

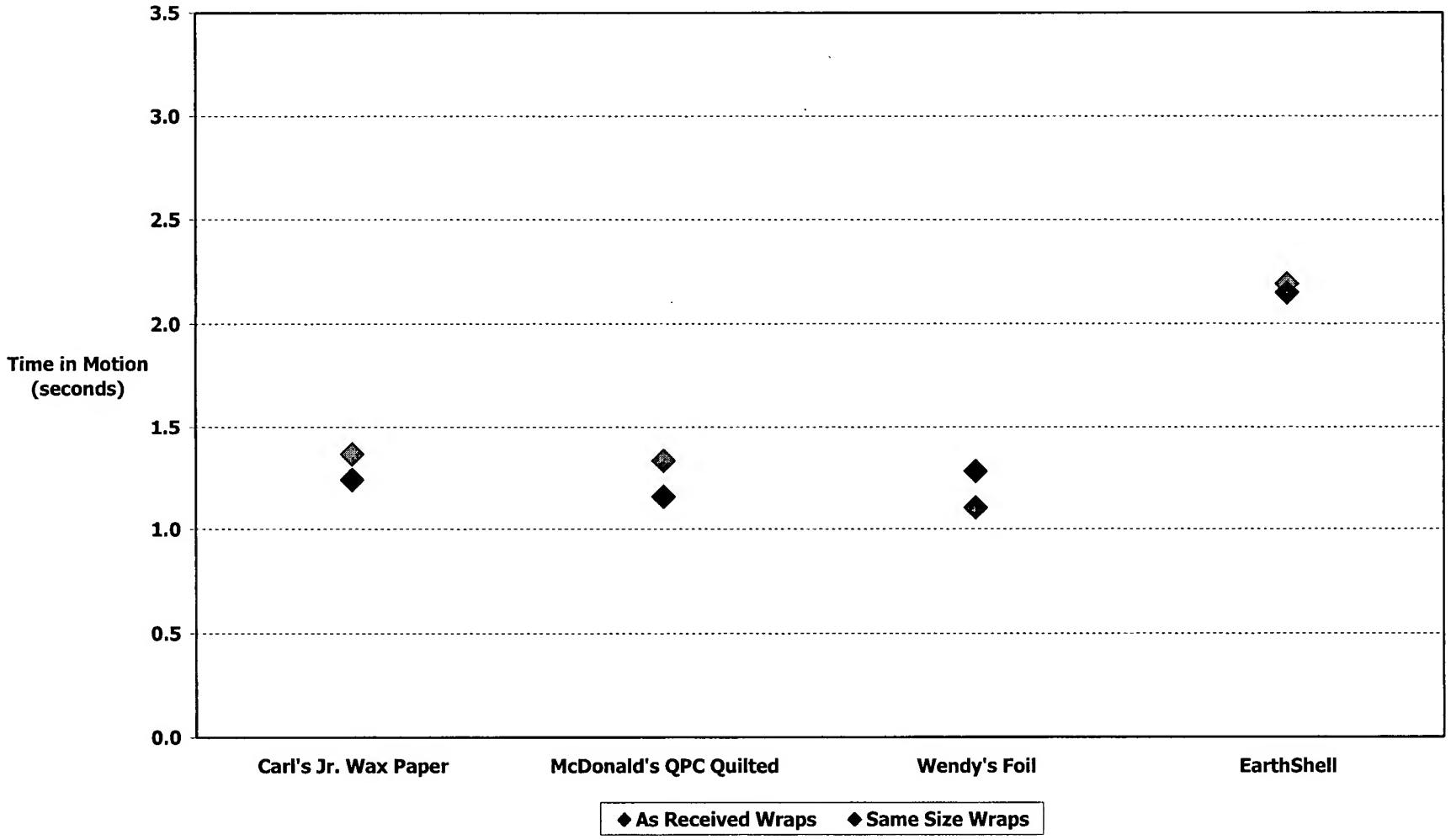


Figure 3. Time in Motion of EarthShell and Competitor Wraps

EarthShell CORPORATION

Interoffice Memorandum

To: Kishan Khemani

From: Deni Miller

Date: September 21, 2001

Subject: Mechanical Properties of Printed Monolayer and MDO Monolayer Sandwich Wraps

Cc: Patricia Fredlund, Per Andersen, Amitabha Kumar, Randy Smith

Keywords: *mechanical properties, wrap, monolayer, MDO*

The mechanical properties of two monolayer sandwich wraps were determined at low and high strain rates. The results of the tensile tests at strain rates of 200 and 1000 mm/minute and the elongation at a strain rate of 10 mm/minute are contained in Table 1. Figures 1-3 compare the peak stress, peak strain and modulus for the different strain rates and testing directions.

Table 1. Tensile Test Results at Low and High Strain Rates

Machine Direction

Wrap	Strain Rate (mm/min)	Peak Stress (MPa)	Peak Strain (%)	Modulus[2] (MPa)
Printed monolayer[1]	200	17 ± 1	1234 ± 30	625 ± 49
MDO monolayer	200	12 ± 1	415 ± 4	646 ± 75
Printed monolayer	1000	17 ± 0	1162 ± 58	
MDO monolayer	1000	14 ± 1	434 ± 105	

Cross Direction

Construction	Strain Rate (mm/min)	Peak Stress (MPa)	Peak Strain (%)	Modulus[2] (MPa)
Printed monolayer	200	9 ± 0	156 ± 58	534 ± 61
MDO monolayer	200	9 ± 1	27 ± 10	677 ± 149
Printed monolayer	1000	11 ± 1	50 ± 8	
MDO monolayer	1000	9 ± 2	22 ± 2	

[1] Two out of three samples did not break.

[2] Separate test with a strain rate of 10 mm/minute.

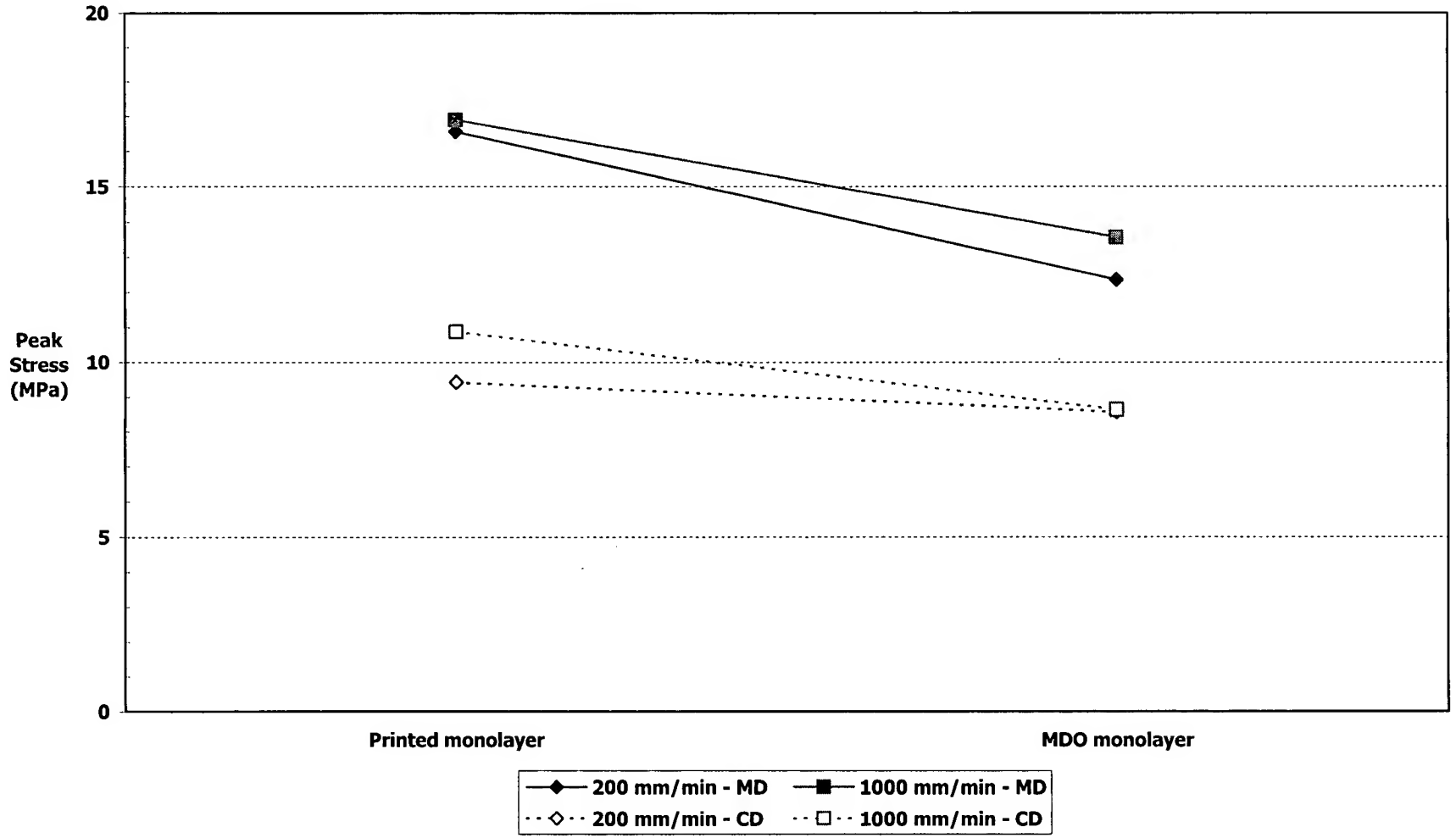


Figure 1. Peak Stress of Wraps as a Function of Strain Rate

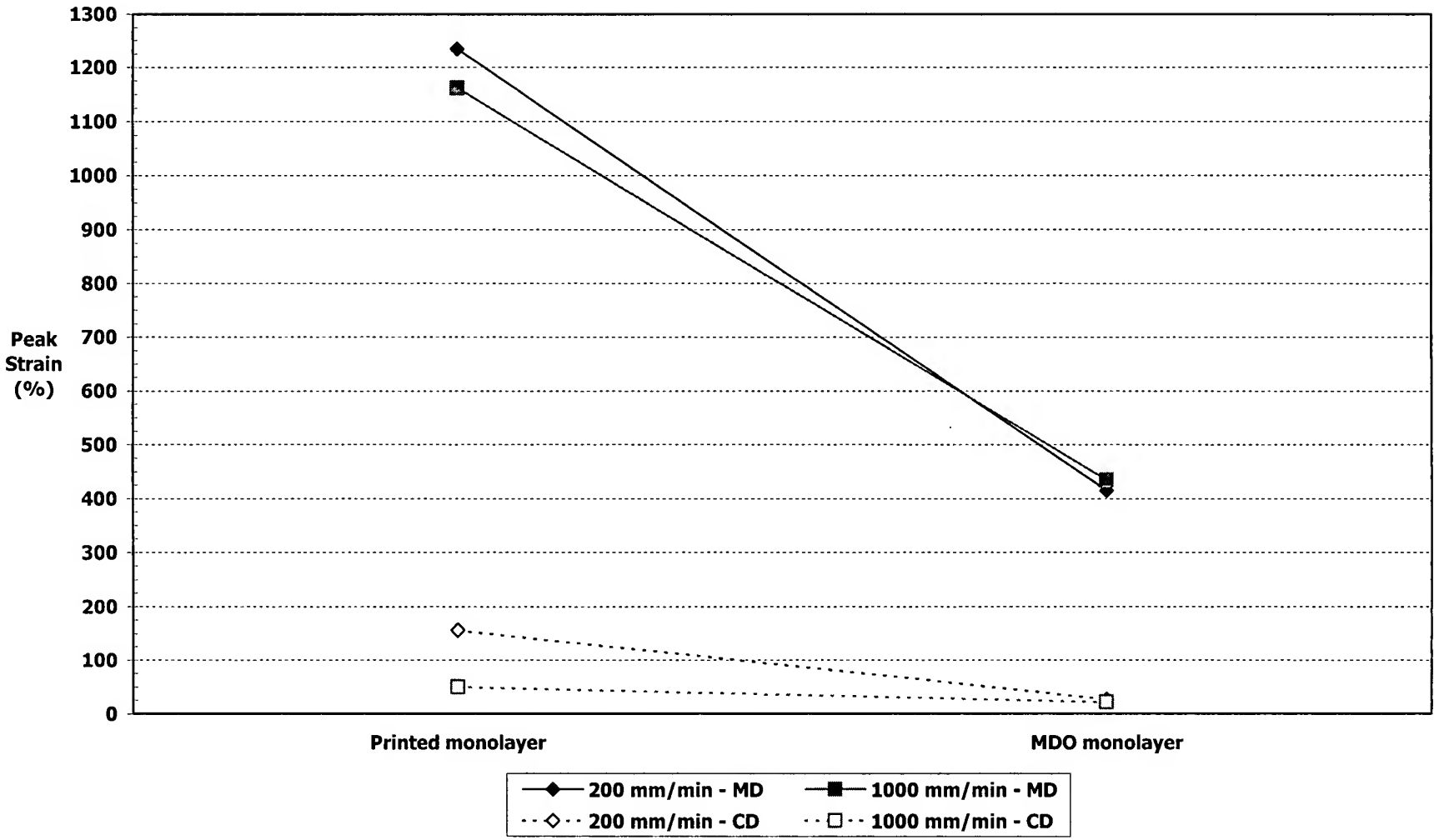


Figure 2. Peak Strain of Wraps as a Function of Strain Rate

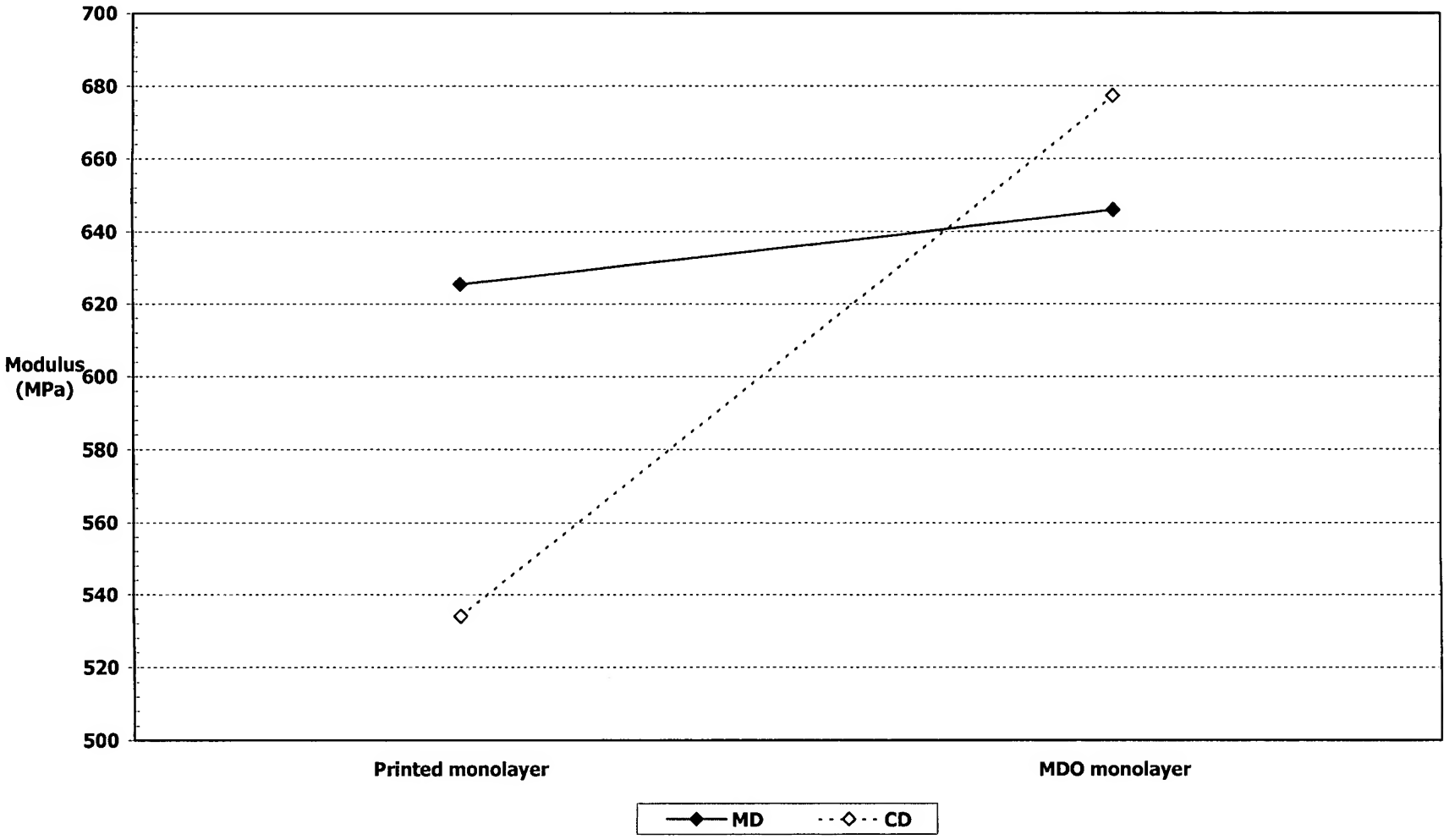


Figure 3. Modulus of Wraps as a Function of Testing Direction

Monolayer MDO Wrap Film

Processing Guidelines

Materials:

DuPont: Biomax 4026 resin containing 0.20% silica.

Eastman: Eastar Bio GP resin.

A. Schulman Inc.: T4338-ES masterbatch using the Eastar Bio GP resin and $CaCO_3$ and TiO_2

Wrap Composition:

The monolayer MDO wrap consists of extruding cast-MDO film from a blend of 50% T4338-ES masterbatch and 50% Biomax resin. This blend gives a final composition of 50% Biomax, 35% fillers, and 15% Eastar Bio in the finished product.

Drying:

The Eastar Bio resin and the T4338-ES Masterbatch should be dried at 150°F for 4-6 hours to -40°F dew-point or 80 ppm resin moisture level and store in sealed foil lined bags. The Biomax resin should be dried at 200°F for 10 hours to -40°F dew-point or 50 ppm resin moisture level and store in sealed foil lined bags.

Equipment:

Avery Dennison cast film line (E-1/2):

This is a four layer line consisting of four extruders, with one 2.5" diameter main extruder, and three 1.5" diameter side-extruders. It is also equipped with an AB Cloeren feed block, and a 24" width die and a matte finished chill roll. It is further equipped with a machine direction orienter (MDO) in the downstream. The line is also equipped with an automatic continuous gage control unit.

For this Monolayer MDO wrap film, use only the 2.5" main extruder.

Suggested line profile for the production of Monolayer MDO Wrap film:

The extruder and downstream processing profile for the production of wrap films from the above mix design is noted below:

Barrel Zones:	1	2	3	4	5	6	7	8	9	10
Set °F:	400	410	410	410	380	390	390	370	380	380

Die Heat:

Zones:	1	2	3	4	5	6	7	8	9	10	11
Set °F:	410	410	410	410	410	410	410	410	410	410	410

Extruder pressure: 1200 psi

MDO Rolls:

	Pre-heat Rolls	Post-heat Rolls
Set temperature °F	192/165	173/175

MDO ratio: 1 : 2.6 x

Film Gage:

The target gage for Monolayer MDO wrap is between 1.1 – 2.3 mils (pre-MDO gage of 3 – 6 mils; e.g. 4.7 mils film was MDO to ~1.8 mil gage).

EarthShell CORPORATION

Product Specification

Title: **Competitive Wrap: Taco Bell Chalupa Quilted Paper**

Basis Weight: By Layers – (outside) 15 lbs/ream MG paper (±5%)
(middle) 5 lb polyethylene (±5%)
(inside) 10.75 lbs/ream paper (±5%)

Sheet Caliper: Total sheet claiper: 0.95 mil target (±5%)

Brightness, TAPPI T-452 (%): 83 Minimum

Opacity, TAPPI T-425 (%): 70 Minimum

WVTR @ 73F & 50% RH, ASTM F1249 (gm/100 in^2 * 24 hr)
0.40-0.49

Tensile, Wet, TAPPI T-456 (lb/in):
MD 2.14-10.87
CMD 1.06-7.3

Tear, Elemendorf, TAPPI T-414 (gm):
MD 17.2-38.4
CD 19.2-44.0

Coefficient of Friction @73F & 50% RH, TAPPI T-549:
Static 0.34-0.48
Kinetic 0.33-0.47

Dimensions: 12" x 12" square ± 1/8"

Packing: 2,500 wraps per case

EarthShell CORPORATION

Product Specification

Title: **Wrap – A (Papermatch) – 'EarthShell' Print**

Basis Weight: **12"x12"** 7.37 lbs / 1000 sq. ft, or 3.35 grams / wrap (± 10%)
10.5"x13" 7.37 lbs / 1000 sq. ft, or 3.17 grams / wrap (± 10%)

Sheet Caliper (observed): 1.8 mil (± 10%)

Brightness, TAPPI T-452 (%): 83.2 Minimum

Opacity, TAPPI T-425 (%): 67.4 Minimum

WVTR @ 20C & 50% RH, ASTM F1249 (gm/100 in^2 * 24 hr)
1.45

Tensile, Wet, TAPPI T-456 (lb/in):
MD 1.48
CMD 1.26

Tear, Elemendorf, TAPPI T-414 (gm):
MD 12.84
CD 10.23

Coefficient of Friction @73F & 50% RH, TAPPI T-549:
Static 0.47
Kinetic 0.36

Dimensions: 12" x 12" square ± 1/8"
10.5" x 13" square ± 1/8"

Packing: 2,500 wraps per case